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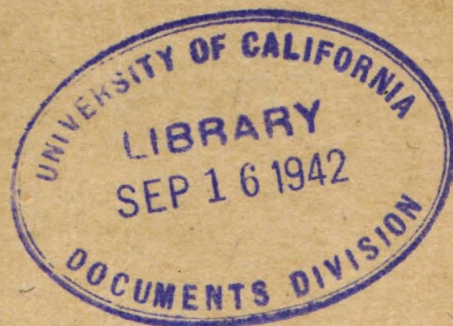
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U.S. Dept. of Army

**WAR DEPARTMENT**  
**TECHNICAL MANUAL**

**COAST ARTILLERY**  
**GUNNERS' INSTRUCTION**  
**ANTIAIRCRAFT ARTILLERY**  
**EXPERT GUNNERS**

April 28, 1942



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**TECHNICAL MANUAL**

**COAST ARTILLERY GUNNERS' INSTRUCTION, ANTI-AIRCRAFT ARTILLERY, EXPERT GUNNERS**

CHANGES  
No. 8/

WAR DEPARTMENT,  
WASHINGTON 25, D. C., 16 July 1943.

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BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,  
*Chief of Staff.*

OFFICIAL:

J. A. ULIO,  
*Major General,  
The Adjutant General.*

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# COAST ARTILLERY GUNNERS' INSTRUCTION

## ANTIAIRCRAFT ARTILLERY

### EXPERT GUNNERS

|   | Paragraphs |
|---|------------|
| CHAPTER 1. General .....  | 1-2        |
| CHAPTER 2. Motor transportation.  |            |
| SECTION I. Principles of internal combustion engines.....                       | 3-13       |
| II. Inspection and maintenance of motor vehicles.....                           | 14-23      |
| III. Shop practices; supervision and instruction of<br>mechanics .....          | 24-26      |
| IV. Loads and their proper distribution.....                                    | 27         |
| V. Training of drivers.....   | 28         |
| VI. Convoy discipline, rules of the road, and road<br>inspections .....         | 29-33      |
| VII. March rules and discipline.....  | 34-36      |
| VIII. Records and reports, motor transportation....                             | 37         |
| IX. Care, service, repair, and maintenance of motor<br>vehicles in field .....  | 38-45      |
| CHAPTER 3. Communication.   |            |
| SECTION I. Systems of communication.....  | 46-49      |
| II. Visual signaling—panels.....  | 50         |
| III. Installation of field telephone system.....                                | 51-53      |
| IV. Location of faults; tests for grounds and short<br>circuits .....           | 54         |
| V. Installation and operation of message centers;<br>encoding and decoding..... | 55-56      |
| VI. Linemen and telephone and switchboard oper-<br>ators.....                   | 57         |
| VII. Dissemination of alarms; records and reports..                             | 58-59      |
| CHAPTER 4. Observation and position finding.                                    |            |
| SECTION I. Position-finding system.....   | 60         |
| II. Position-finding apparatus.....   | 61-66      |
| III. Observation and adjustment of fire.....                                    | 67-69      |
| IV. Orientation—use of transit.....   | 70-72      |
| V. Indication and identification of targets.....                                | 73-77      |
| VI. General duties of observers.....  | 78         |
| VII. Operation of antiaircraft spotting set.....                                | 79-85      |
| VIII. Operation of meteorological section.....                                  | 86-89      |

|  |             |
|--|-------------|
| CHAPTER 5. Antiaircraft gun firing section.  | Paragraphs  |
| SECTION I. Gun and mount-----  | 90-94       |
| II. Duties of members of firing section-----   | 95          |
| III. Ammunition—basic -----  | 96-97       |
| IV. Preparation for service practice-----  | 98-100      |
| V. Pointing and firing-----  | 101-103     |
| CHAPTER 6. Antiaircraft gun range section.   |             |
| SECTION I. Duties of members of range section-----                                   | 104         |
| II. Elementary gunnery-----  | 105-108     |
| III. Records and reports; analysis of target<br>practice-----                        | 109         |
| CHAPTER 7. Data transmission systems for guns-----                                   | 110-113     |
| CHAPTER 8. Automatic weapons.  |             |
| SECTION I. Machine guns-----   | 114-121     |
| II. 37-mm guns -----   | 122-125     |
| III. Duties of members of squad or section-----                                      | 126         |
| IV. Selection of position and emplacement-----                                       | 127-128     |
| V. Preparation for service practice-----   | 129-131     |
| CHAPTER 9. Searchlights.   |             |
| SECTION I. Searchlight apparatus-----  | 132-139     |
| II. Troubles and remedies-----   | 140-144     |
| III. Sound locator apparatus -----   | 145-149     |
| IV. Tactical employment of searchlight section-----                                  | 150-151     |
| CHAPTER 10. General subjects.  |             |
| SECTION I. Definitions and elementary principles for<br>antiaircraft artillery ----- | 152-154     |
| II. Organization of position or bivouac-----   | 155-158     |
| III. Map reading -----   | 159-162     |
| IV. Elementary principles of electricity, mag-<br>netism, and induction-----         | 163-164     |
| V. Ammunition—advanced-----  | 165-166     |
| INDEX-----   | Page<br>354 |

## CHAPTER 1

### GENERAL

|                           |                |
|---------------------------|----------------|
| Purpose and scope-----    | Paragraph<br>1 |
| Assignment of topics----- | 2              |

1. **Purpose and scope.**—*a. Purpose.*—This manual is designed primarily for use by organization commanders in the instruction of enlisted men of antiaircraft artillery units of the Coast Artillery

Corps. It may also be used by officers conducting examinations of enlisted men for qualification as gunners as contemplated by FM 4-150. The questions and answers are intended merely as a guide and should be supplemented by the extensive use of other questions and answers and by practical demonstrations.

*b. Scope.*—The topics included in this manual are those prescribed in FM 4-150 for qualification of enlisted men as expert gunners in the units indicated in paragraph 2.

**2. Assignment of topics.**—The following is the general assignment of topics. Each organization should omit those portions of the assigned chapters, sections, and paragraphs that do not pertain to the particular equipment in use by the organization.

| Subject  | Transportation sergeant or truckmaster | Communication sergeant |
|--|--|------------------------|
| Principles of internal combustion engines.   | Sec. I, ch. 2-----                     |                        |
| Inspection and maintenance of motor transportation.  | Sec. II, ch. 2-----                    |                        |
| Elementary principles of electricity, magnetism, and induction.  | Sec. IV, ch. 10---                     | Sec. IV, ch. 10.       |
| Shop practices, supervision and instruction of mechanics.  | Sec. III, ch. 2-----                   |                        |
| Loads and their proper distribution-----   | Sec. IV, ch. 2-----                    |                        |
| Training of drivers-----   | Sec. V, ch. 2-----                     |                        |
| Detailed knowledge of rules of the road, convoy regulations and discipline, speed laws and regulations, parking, and road inspections.   | Sec. VI, ch. 2-----                    |                        |
| Records and reports, motor transportation.   | Sec. VIII, ch. 2--                     |                        |
| Systems of communication-----  | -----                                  | Sec. I, ch. 3.         |
| Visual signaling—panels-----   | -----                                  | Sec. II, ch. 3.        |
| Installation of a complete field telephone system required by the unit.  | -----                                  | Sec. III, ch. 3.       |
| Data transmission systems (gun batteries only). (See note 1.)  | -----                                  | Ch. 7.                 |
| Practical knowledge of the available means and methods for dissemination of antiaircraft artillery intelligence alarms, alerts, flash messages, records, and reports (all except gun batteries). (See note 1.) | -----                                  | Sec. VII, ch. 3.       |
| Location of faults, tests for grounds, and tests for short circuits.   | -----                                  | Sec. IV, ch. 3.        |

NOTE 1.—Either of these two subjects may be required of communication sergeants of battalion headquarters batteries.

| Subject  | Transportation sergeant<br>or truckmaster | Communication sergeant |
|--|---|------------------------|
| Installation and operation of message centers, encoding and decoding.                  | -----                                     | Sec. V, ch. 3.         |
| Ability to instruct in the duties of line-men and telephone and switchboard operators. | -----                                     | Sec. VI, ch. 3.        |

| Subject   | Gun commander or<br>chief of section, gun<br>battery | Chief of section or pla-<br>toon sergeant, ma-<br>chine-gun or 37-mm<br>gun battery |
|---|--|---|
| Definitions and elementary principles for antiaircraft artillery.                                       | Sec. I, ch. 10-----                                  | Sec. I, ch. 10.   |
| Gun and mount-----  | Sec. I, ch. 5, and<br>ch. 7.                         | Secs. I and II,<br>ch. 8.   |
| Ability to instruct in the duties of each member of the gun section (or machine-gun squad) (practical). | Sec. II, ch. 5-----                                  | Sec. III, ch. 8.  |
| Selection of position and emplacement-----  | -----  | Sec. IV, ch. 8.   |
| Organization of a position-----   | Sec. II, ch. 10-----                                 | Sec. II, ch. 10.  |
| Ammunition-----   | Sec. III, ch. 5-----                                 | -----   |
| Preparations for service practice-----  | Sec. IV, ch. 5-----                                  | Sec. V, ch. 8.  |
| Pointing and firing-----  | Sec. V, ch. 5-----                                   | -----   |
| Map reading-----  | Sec. III, ch. 10-----                                | Sec. III, ch. 10.   |
| March rules and discipline-----   | Sec. VII, ch. 2-----                                 | Sec. VII, ch. 2.  |

| Subject  | Chief of range section,<br>gun battery | Chief of section, search-<br>light battery         |
|--|--|--|
| Definitions and elementary principles for antiaircraft artillery.                  | Sec. I, ch. 10-----                    | Sec. I, ch. 10.                                    |
| Position-finding system-----   | Sec. I, ch. 4-----                     | -----  |
| Position-finding apparatus-----  | Sec. II, ch. 4-----                    | -----  |
| Ability to instruct in the duties of each member of the range section (practical). | Sec. I, ch. 6-----                     | -----  |
| Elementary gunnery-----  | Sec. II, ch. 6, and<br>par. 86.        | -----  |
| Methods of observation and how to apply corrections.                               | Sec. III, ch. 4-----                   | -----  |
| Preparation of records and reports-----  | Sec. III, ch. 6-----                   | -----  |
| Searchlight apparatus-----   | -----                                  | Sec. I, ch. 9.                                     |
| Sound-locator apparatus-----   | -----                                  | Sec. III, ch. 9.                                   |
| Troubles and remedies-----   | -----                                  | Sec. II, ch. 9.                                    |
| Tactical employment of the searchlight section.                                    | -----                                  | Sec. IV, ch. 9, and<br>pars. 155, 156,<br>and 158. |
| Map reading-----   | -----                                  | Sec. III, ch. 10.                                  |
| March rules and discipline-----  | -----                                  | Sec. VII, ch. 2.                                   |

| Subject  | Instrument sergeant,<br>gun battery | Observer, headquarters<br>battery  |
|--|-------------------------------------|------------------------------------|
| Definitions and elementary principles for antiaircraft artillery.                  | Sec. I, ch. 10-----                 | Sec. I, ch. 10.                    |
| Position-finding system-----   | Sec. I, ch. 4-----                  | Sec. I, ch. 4.                     |
| Position-finding apparatus-----  | Sec. II, ch. 4-----                 | Sec. II, ch. 4.                    |
| Method of observation and how to apply corrections.                                | Sec. III, ch. 4-----                |                                    |
| Map reading-----   | Pars. 159 and 160-----              | Pars. 159 and 160.                 |
| Duties of an assistant in the use of a transit in establishing a battery position. | Sec. IV, ch. 4-----                 | Sec. IV, ch. 4.                    |
| Organization of a position-----  | Sec. II, ch. 10-----                | Sec. II, ch. 10.                   |
| Detailed knowledge of the indication and identification of targets.                | Sec. V, ch. 4-----                  | Sec. V, ch. 4.                     |
| Detailed knowledge of the spotting system in use by the combat units.              | -----                               | Par. 79.                           |
| Observation of fire-----   | -----                               | Sec. III, ch. 4.                   |
| General duties of observers in observation posts.                                  | -----                               | Sec. VI, ch. 4.                    |
| Operation of the antiaircraft spotting set (spotting camera).                      | -----                               | Sec. VII, ch. 4.<br>(See note 1.)  |
| Operation of the meteorological section-----                                       | -----                               | Sec. VIII, ch. 4.<br>(See note 1.) |

NOTE 1.—Either of these two subjects may be substituted for "Duties of an assistant in the use of a transit in establishing a battery position."

| Subject  | Chief of section, ammunition train |
|--|------------------------------------|
| Detailed knowledge of the care, service, repair, and maintenance of motor vehicles in the field.   | Sec. IX, ch. 2.                    |
| Detailed knowledge of procuring, handling, and storage of ammunition under all conditions of service.                                      | Par. 165.                          |
| Loads and their proper distribution-----   | Sec. IV, ch. 2.                    |
| Training of drivers-----   | Sec. V, ch. 2.                     |
| Organization of a bivouac-----   | Sec. II, ch. 10.                   |
| Detailed knowledge of the rules of the road, convoy regulations and discipline, speed laws and regulations, parking, and road inspections. | Sec. VI, ch. 2.                    |
| Ammunition records, reports, and forms-----  | Par. 165.                          |

## CHAPTER 2

### MOTOR TRANSPORTATION

|   | Paragraphs |
|---|------------|
| SECTION I. Principles of internal combustion engines.....                     | 3-13       |
| II. Inspection and maintenance of motor vehicles.....                         | 14-23      |
| III. Shop practices; supervision and instruction of<br>mechanics .....        | 24-26      |
| IV. Loads and their proper distribution.....                                  | 27         |
| V. Training of drivers.....   | 28         |
| VI. Convoy discipline, rules of the road, and road<br>inspections .....       | 29-33      |
| VII. March rules and discipline.....  | 34-36      |
| VIII. Records and reports, motor transportation.....                          | 37         |
| IX. Care, service, repair, and maintenance of motor<br>vehicles in field..... | 38-45      |

## SECTION I

### PRINCIPLES OF INTERNAL COMBUSTION ENGINES

|   | Paragraph |
|---|-----------|
| Theory of internal combustion engine..... | 3         |
| Gasoline feed system.....                 | 4         |
| Ignition system.....                      | 5         |
| Lubrication system.....                   | 6         |
| Cooling system.....                       | 7         |
| Storage batteries.....                    | 8         |
| Generators.....                           | 9         |
| Power transmission and running gear.....  | 10        |
| Axles and wheels.....                     | 11        |
| Brakes .....                              | 12        |
| Steering gear.....                        | 13        |

**3. Theory of internal combustion engine.**—*Q.* Explain briefly the basic principle involved in the operation of the internal combustion engine.—*A.* A combustible mixture of fuel (gasoline) and oxygen (air) is introduced into a cylinder and compressed between the closed end of the cylinder and a piston. The mixture is then ignited. The burning of the mixture generates heat which causes expansion of the gases within the cylinder. The expanding gases act on the piston and force it downward. The movement of the piston is transmitted through a connecting rod to the crankshaft, thus converting heat energy into mechanical energy.

*Q.* What types of internal combustion engines are used in motor vehicles?—*A.* The gasoline engine and the Diesel engine.

*Q.* What is meant by a cycle?—*A.* A cycle is a series of events which are constantly repeated in the same manner and the same order. In a gasoline engine it consists of the four strokes of the piston and the events that occur with each stroke.

*Q.* What is meant by a four-cycle or four-stroke engine?—*A.* One whose cycle consists of four distinct steps:

- (1) Intake or admission of the charge of the air-fuel mixture.
- (2) Compression of the charge.
- (3) Ignition and explosion of the charge.

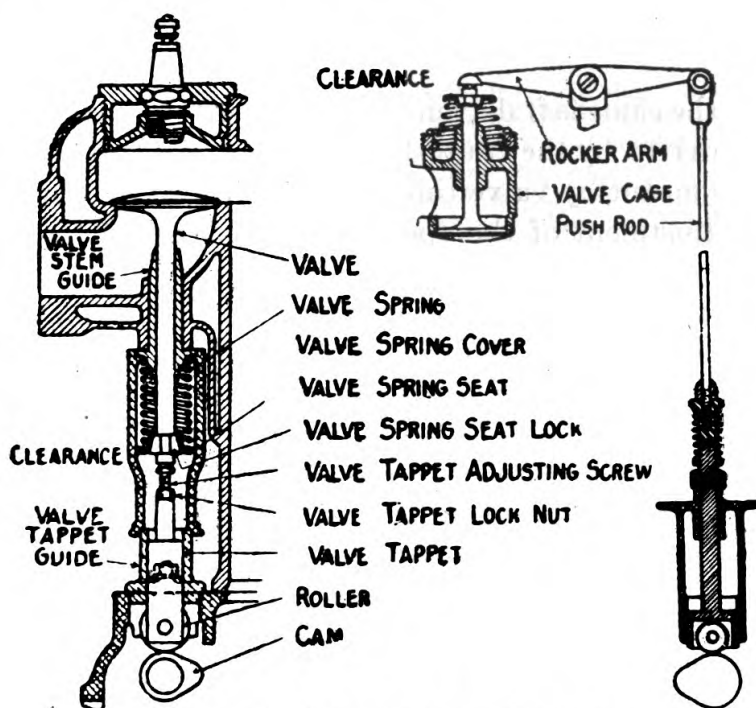


FIGURE 1.—Typical valve mechanisms.

- (4) Exhaust or expulsion of the burned charge.

When this complete process requires four strokes of the pistons in any one cylinder, the engine is designated as a four-stroke cycle engine.

*Q.* Explain what takes place during each of the four strokes of the cycle. *A.*—

(1) The piston being at top dead center, the intake valve having just opened, the piston going down on suction draws into the cylinder a charge of gasoline and air.

(2) Shortly after the piston has passed bottom dead center, the intake valve closes, and during the rest of the upward stroke the charge is compressed.

(3) Just before the piston reaches top dead center on the compression stroke, a spark is produced at the spark plug and the burning of the charge forces the piston downward. (This is the power stroke.)

(4) Just before the piston reaches bottom dead center the exhaust valve opens and the next upward stroke of the piston forces the burned gases out and clears the cylinder for the intake stroke of the next cycle.

Q. Why is a system of valves used in an engine?—A. To allow the fuel to enter the combustion chamber, to close the chamber, and to allow the burned gases to escape from the combustion chamber at the proper time.

Q. What is the function of the camshaft?—A. The camshaft has a cam for each valve. As the camshaft turns, the cam comes in contact with the valve lifter and raises the particular valve off its seat (opens it).

Q. How is the camshaft driven?—A. Either by a chain or system of timing gears driven by the crankshaft gear.

Q. What is meant by valve timing?—A. By valve timing is meant the proper adjustment of the opening and closing of the intake and exhaust valves in relation to the position of the piston. Since the distance of the piston from dead center is dependent on the position of the crankshaft, valve timing resolves itself into the proper meshing of the crankshaft gear with the camshaft gear to obtain this correct relationship.

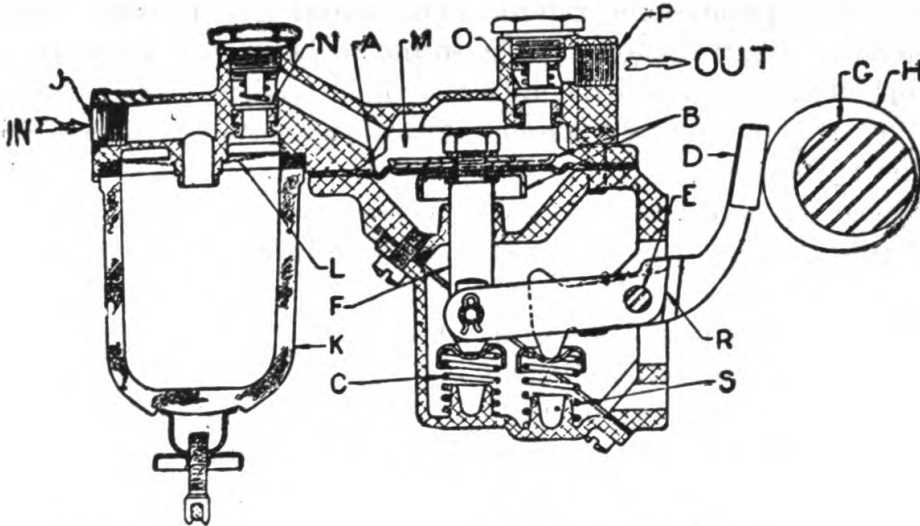
Q. When should the valve open in relation to the position of the piston?—A. The average opening and closing of the valves of the modern high-speed engine is as follows: Intake valve opens  $5^{\circ}$  before top dead center. Intake valve closes  $46^{\circ}$  after bottom dead center. Exhaust valve opens  $47^{\circ}$  before bottom dead center. Exhaust valves close  $8^{\circ}$  after top dead center.

NOTE.—Wherever values for any adjustments are given they should be understood as averages. Service manuals for particular vehicles should always be consulted.

Q. Why is the power-producing unit of a motor vehicle called an engine instead of a motor?—A. To avoid any confusion with electric or starting motors.

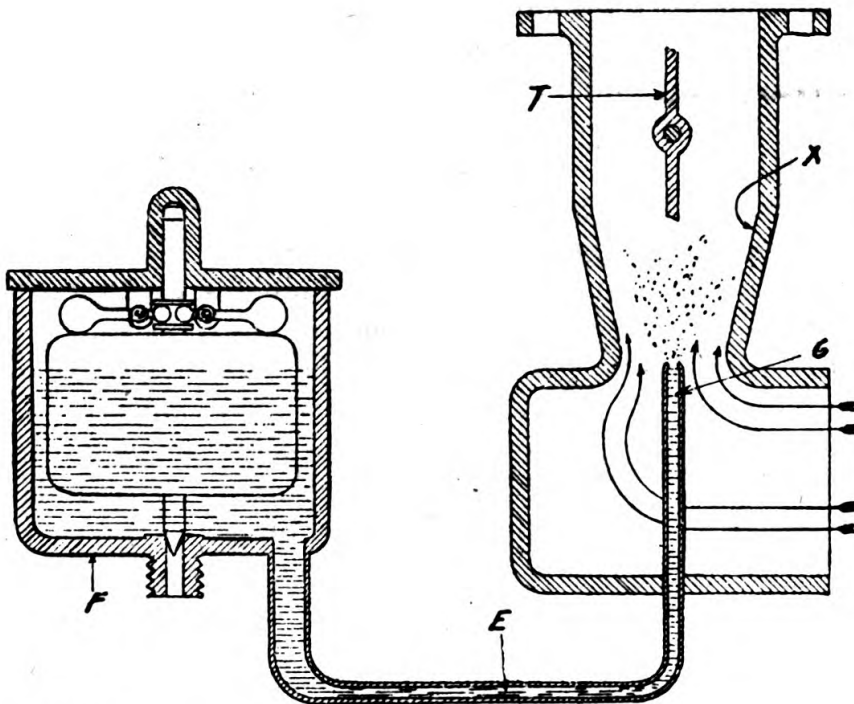
4. **Gasoline feed system.**—Q. What type gasoline feed system is used on Army vehicles?—A. The positive fuel feed system (fuel pump) is used on all modern vehicles.

Q. Describe the fuel pump.—A. The fuel pump is a device used to pump the fuel from the fuel tank and force it to the carburetor. It has a diaphragm in the housing of the pump which is operated by a lever. The lever is in constant contact with a cam on the cam-



- |   |                          |
|---|--------------------------|
| A. Diaphragm.                                   | J. Inlet from gas tank.  |
| B. Diaphragm metal disks.                       | K. Glass sediment bowl.  |
| C. Diaphragm pull rod spring.                   | L. Sediment bowl screen. |
| D. Diaphragm operating rocker arm (two pieces). | M. Pump chamber.         |
| E. Rocker arm pivot.                            | N. Inlet suction valve.  |
| F. Diaphragm pull rod.                          | O. Pressure valve.       |
| G. Camshaft.                                    | P. Outlet to carburetor. |
| H. Eccentric cam on camshaft.                   | R. Break in rocker arm.  |
|   | S. Rocker arm spring.    |

FIGURE 2.—Fuel pump (sectionalized view).



- |                                |                  |
|--------------------------------|------------------|
| F. Float chamber.              | G. Jet.          |
| T. Throttle (butterfly) valve. | X. Venturi tube. |

FIGURE 3.—Simple carburetor.

shaft which operates the pump. The pump has a check valve in the inlet side which allows the gasoline to be drawn from the fuel tank but stops the flow back into the tank. There is another check valve on the outlet side which allows the gasoline to be forced into the carburetor.

*Q.* What troubles develop most frequently in a fuel pump?—*A.* The diaphragm becomes punctured, gasoline lines become loose, or the strainer becomes clogged.

*Q.* What pump parts should be carried on a convoy?—*A.* A complete fuel pump for replacement use.

*Q.* Name the essential parts of a carburetor.—*A.* The carburetor throat, float chamber, float, float needle valve, low- and high-speed nozzles, primary and secondary air inlet, throttle valve, and choke valve.

*Q.* Why must a carburetor have a compensating device on it?—*A.* The increase in rate of flow of air and fuel is not proportional, the increase in flow of fuel being much greater than that of air.

*Q.* What methods of compensation are used in the construction of carburetors? *A.*—

(1) Automatically supplying a proportionate increase in fuel as the suction decreases.

(2) Increasing the air proportionately as the suction increases.

*Q.* Name some of the compensating devices used in carburetors.—*A.* Auxiliary jet, metering pin, expanding venturi, compensating jet, air bleed system, and multiple jet.

*Q.* What is the advantage of a down-draft carburetor?—*A.* The flow of fuel, being downward instead of upward, is aided by gravity, thereby increasing the capacity, while cooler air will enter at the top of the engine, giving an increase of power. This carburetor is more easily installed and it partially eliminates fire hazards, since a backfire will be in the air above the engine.

**5. Ignition system.**—*Q.* What are the necessary parts of a battery ignition system?—*A.* A storage battery; switch; primary circuit consisting of the breaker (or interrupter), condenser, and primary coil; and the secondary circuit, consisting of secondary coil, distributor, high-tension cables, and spark plugs.

*Q.* What is the function of the ignition system?—*A.* To ignite the charge of fuel at the proper time.

*Q.* What is meant by ignition timing?—*A.* Setting the ignition system so the breaker points will start to open at, or just before, the piston reaches top dead center on the compression stroke.

Q. What is the source of electrical power to operate the ignition system on the modern automobile?—A. The storage battery, and generator.

Q. Draw a wiring diagram of a typical battery ignition system.—A. See figure 4.

Q. What is the difference between the primary and secondary windings? A.—

(1) The primary winding has a small number of turns of large wire wound on a soft iron core. The voltage of the primary is from 6 to 12 volts, depending on the voltage of the battery.

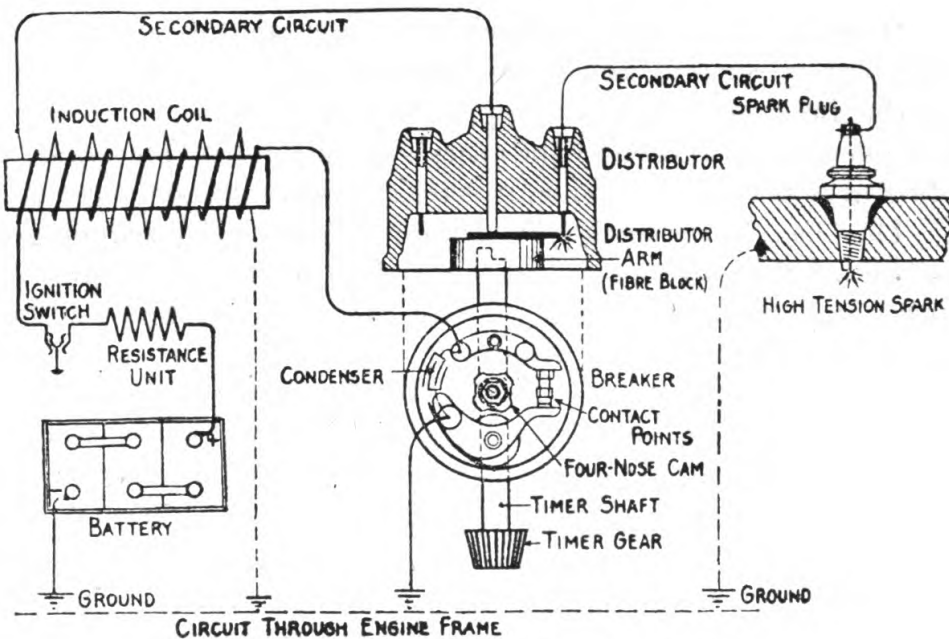


FIGURE 4.—Typical battery ignition system.

(2) The secondary coil has many turns of fine wire wound on the primary coil. The primary coil, aided by the condenser action, induces a voltage of several thousand volts in the secondary coil.

Q. What is the interrupter?—A. The interrupter is a mechanical switch which rapidly makes and breaks the primary circuit at intervals. When the primary circuit is broken the primary current ceases to flow, thus causing the magnetic field around the coil to collapse. In so doing, it will induce a high voltage in the secondary coil having sufficient intensity to cause the secondary current to jump the spark plug gap.

Q. Explain the construction of the interrupter.—A. The interrupter consists of a stationary contact point and a movable contact point, a spring which tends to keep them together, and a rotating cam which separates them at regular intervals. The cam is geared

to the camshaft and the speed of the cam is proportional to the engine speed.

Q. What is the ratio of the camshaft to crankshaft speed?—A. The camshaft speed is half the speed of the crankshaft.

Q. Of what does a condenser consist?—A. It consists of two strips of tinfoil separated by insulation and folded into a convenient size. The two strips of tinfoil are connected to separate terminals so that there is no electrical connection between them.

Q. What is the purpose of the condenser?—A. The condenser is used in the primary circuit in parallel with the breaker points. When the breaker points open and the primary circuit is broken, the induced-kick voltage in the primary, which is in the same direction as the original battery current and which otherwise would cause an arcing across the breaker points, is impressed across the condenser and charges one side positive and the other side negative. The condenser will discharge back in a reverse direction through the primary windings. This backward surge of current will assist in reducing the magnetism of the core to zero, thus speeding up the collapsing lines of force and thereby aiding in securing the maximum induced voltage in the secondary winding.

Q. Describe the distributor head.—A. The distributor head has a center terminal which connects with the secondary terminal of the induction coil, and has as many metal segments or terminals equally spaced around it as there are cylinders. Mounted on the distributor shaft is a rotating finger which turns at one-half crankshaft speed and makes contact with one of the terminals on the distributor. Just before the breaker points are opened, this center terminal makes contact with the rotor finger, thus closing the circuit from the induction coil to the spark plug when the piston is on top dead center (or firing point).

Q. What should the gap at the breaker points be?—A. It should be from about 0.013 to 0.022 of an inch.

Q. What should the spark plug gap be?—A. It should be from 0.025 to 0.035 of an inch.

Q. What should the valve tappet clearance be?—A. The exhaust valve tappet should have about 0.006 to 0.012 of an inch. The inlet valve tappet should have about 0.004 to 0.010 of an inch.

**6. Lubrication system.**—Q. Name and explain the lubrication systems used in automobile engines.—A. The full-force feed, and the force feed (or pressure feed).

(1) In full feed, an oil pump, which is usually driven from the camshaft by means of gears, picks up the oil from the oil sump.

The oil is then forced upward and conducted by means of tubes to the crankshaft bearings. These bearings become lubricated while the excess oil flows through holes drilled in the crankshaft and through the throws of the crankshaft into the crankpins lubricating the connecting-rod bearings. The oil is forced from the connecting-rod bearing through tubes or holes drilled in the connecting rods to the piston pins. This is the only system in which the oil is forced to the piston pins. In the full-force feed the camshaft bushings are also force-feed lubricated.

(2) In the force feed, the oil is pumped from the oil sump and forced to the crankshaft and connecting-rod bearings only. The piston pins and cylinder walls are lubricated by splash.

*Q.* Explain the oiling system used on the Chevrolet.—*A.* This system provides positive pressure lubrication to the crankshaft main bearings, the camshaft bearings, and valve rocker arm bushings. The oil is taken from the oil pan by the pump which delivers it under pressure to a common bearing lubrication point in the center of the engine and to the oil distributor on the left side of the engine. The center main and center camshaft bearings are lubricated directly from the common bearing lubrication point, and distributing pipes which extend the full length of the crankcase deliver oil to the front and rear main and camshaft bearings. From the low-pressure side of the oil distributor, oil is fed to the connecting-rod dipper troughs in the oil pan to provide positive splash lubrication for the connecting-rod bearings, piston pins, and cylinder walls.

*Q.* Why are oil filters used?—*A.* To remove the dirt and grit from the oil.

*Q.* What types of pumps are used in lubrication systems? *A.*—The gear type, the vane type, and the plunger type.

*Q.* How are lubricating oils classified?—*A.* Lubricating oils are classified according to their viscosity by an SAE rating. By this rating the higher number is given to the heavier oil. Oil with an SAE No. 50 rating is a thick oil, while No. 20 is a thin oil.

*Q.* Should an oil with the same viscosity number be used in winter and summer? Why?—*A.* No. An oil with a high viscosity rating should be used in summer, and an oil with a lower viscosity rating should be used in winter. If a heavy oil is used in the winter it could not lubricate all the bearings properly, because it is too thick to flow through the small clearance that a bearing has during the warming up of the engine.

*Q.* What is meant by crankcase dilution?—*A.* It is the gasoline passing from the combustion chamber, along the cylinder walls,

past the piston rings, down into the crankcase, and mixing with the oil.

**7. Cooling system.**—*Q.* How are engines cooled?—*A.* There are two general types of cooling systems, the air-cooled and water-cooled.

(1) In the water-cooled engine a water jacket surrounds the cylinders and cylinder head. This water jacket is connected to the radiator by hose connections, one at the top and one at the lower part of the water jacket. A fan driven by the engine circulates air through the radiator. The radiator and jacket are filled with water which circulates through the system either under pressure of a centrifugal pump, or by the difference in weight of hot and cold water (thermo-siphon).

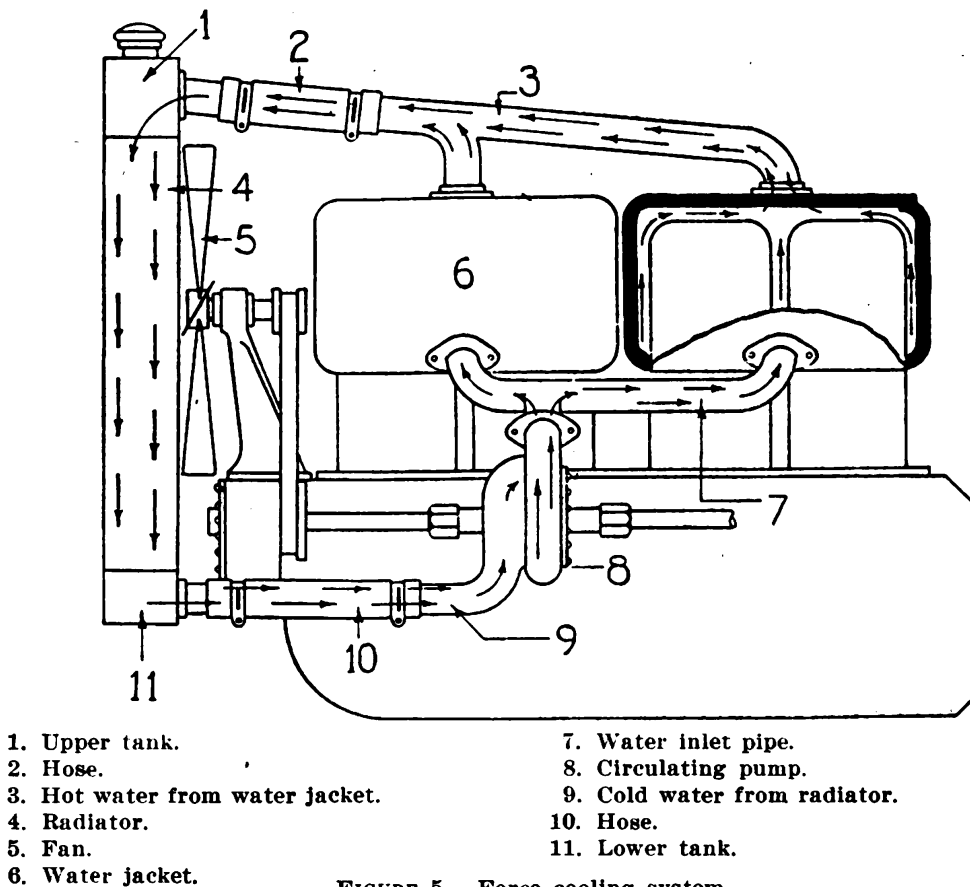


FIGURE 5.—Force cooling system.

(2) In the air-cooled engine the cylinders are cooled by air, circulated by a fan or by the motion of the vehicle. The cylinders have many small fins around them for the purpose of increasing the radiating surface.

*Q.* Should a water-cooled engine be run without water in the cooling system?—*A.* No. It will cause the engine to run hot, and the metal will expand and cause the pistons and rings to seize the cylinder walls due to the burning of oil from the cylinder walls.

**Q.** Should cold water be put in a hot engine?—**A.** No. It may cause the cylinders and cylinder head to crack.

**8. Storage batteries.**—**Q.** Describe the storage battery.—**A.** The lead-acid cell is made of plates of lead and lead oxide immersed in an electrolyte of sulfuric acid and water. The usual or common assembly is to connect these cells in series, that is, with the positive post of one cell connected to the negative post of the next cell and so on to the end of the row. With the cells in series, the voltage of the battery is the sum of the voltage of the cells; the voltage of each lead-acid cell being nominally two volts. The actual voltage at any time, however, depends on the condition of the material of the plates.

**Q.** What should be the specific gravity of—

- (1) A fully charged battery?
- (2) A half-charged battery?
- (3) A fully discharged battery?

**A.** In normal temperatures it should be, respectively:

- (1) 1.300.
- (2) 1.250.
- (3) 1.130 or lower.

**Q.** At what temperature will the following freeze:

- (1) A fully charged battery?
- (2) A fully discharged battery?

**A.** They will freeze at—

- (1) Approximately 96° F. below zero.
- (2) About 32° F. above zero.

**9. Generators.**—**Q.** What is the purpose of the generator?—**A.**

To furnish a charging current for the storage battery, and furnish current for the lights, horn, and ignition when the engine is running.

**Q.** What is the purpose of the reverse current relay?—**A.** It is an automatic electromagnetic switch connected in the battery-charging circuit between the generator and the storage battery. Its purpose is to prevent the current flowing from the battery to the generator when the battery voltage is the higher.

**10. Power transmission and running gear.**—**Q.** What is the purpose of the clutch?—**A.** Its purpose is to connect or disconnect the engine from the transmission, so that the vehicle may or may not move while the engine is running; and also, to allow the engine to be disconnected while shifting gears. A gasoline engine cannot carry the load when starting but must be turning over at a certain speed. The clutch enables the load to be applied gradually after the engine is running.

**Q.** Explain the construction of the plate clutch.—**A.** Advantage is taken of the flywheel to form part of the housing and part of the driv-

ing mechanism of the clutch. The casing of the clutch is integral with the flywheel to which is directly attached the two asbestos friction rings. These friction rings are the driving rings, and are faced with a friction material. The clutch pressure plate contains a number of springs equally distributed on the friction rings which actuate the clutch pressure plate. The shaft which carries the polished steel disk, known as the driven member, is called the clutch shaft. This shaft is supported by a pilot bearing in the flywheel.

*Q.* What is the purpose of the transmission?—*A.* By means of various gears the speed ratio between the engine and the drive shaft

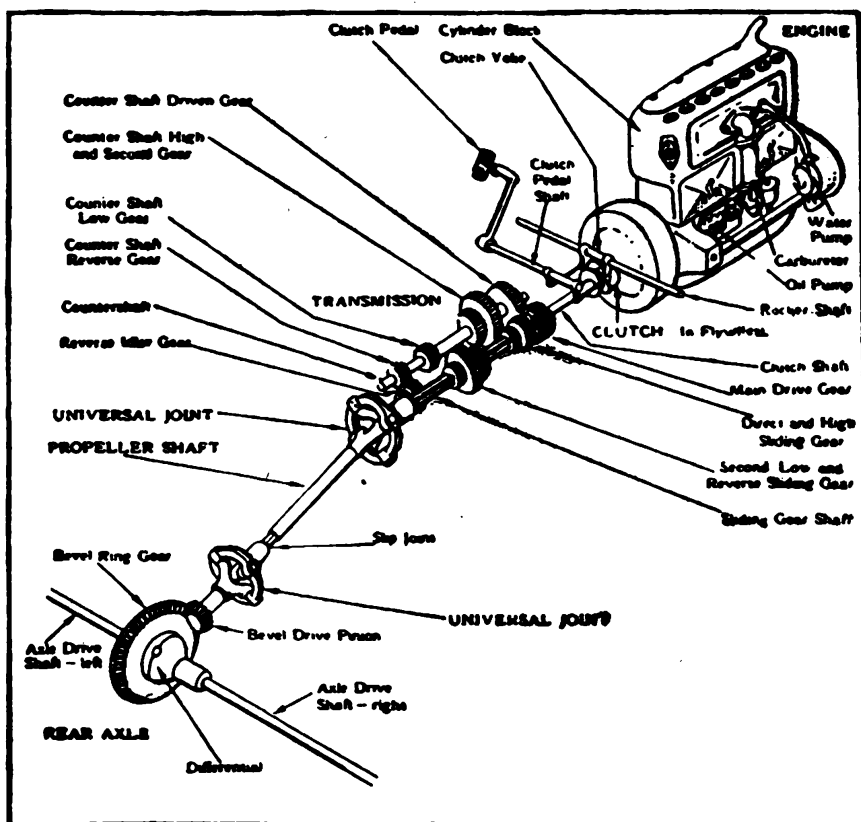


FIGURE 6.—Transmission of power.

can be varied to meet the variations of the load; the direction of the rotation of the drive shaft can be reversed; and all gears can be disengaged so that the engine may be run without operating the driving gear, though the clutch is engaged.

*Q.* Name the classes of transmissions.—*A.* Transmissions are divided into three classes according to their construction and method of operation, and are known as the selective-sliding, synchro-mesh, and constant-mesh, while the motorcycle uses the progressive type. Most of the military trucks have an auxiliary transmission in conjunction with the transmission to obtain a greater driving range.

*Q.* What is the principle of the synchro-mesh transmission?—*A.* Small, cone-type clutches are placed between the driving and driven gears for the direct and intermediate speeds. On shifting into either of these speeds, the clutch comes into action first. This brings the driving and driven gears to the same speed and they may then be meshed without clashing.

*Q.* Explain the auxiliary transmission.—*A.* An auxiliary transmission, sometimes called a subtransmission, is used in direct conjunction with the transmission to obtain greater driving range, and is usually a two-speed transmission having an underdrive and a direct drive. The underdrive has a gear ratio of about 2 to 1, and is provided to give a low total reduction when operating in severe road conditions, or over uneven roads or grades with capacity loads. Direct drive is provided to be used when operating under ordinary road and load conditions and has a gear ratio of 1 to 1; that is, it has no effect on the normal transmission gear ratios.

*Q.* How is the transmission lubricated?—*A.* By heavy oil contained in the transmission.

*Q.* How is the power transmitted to the rear axle?—*A.* Through universal joints and a drive or propellor shaft. Four-wheel-drive trucks employ two-drive shafts and require what is known as a transfer case for this purpose.

*Q.* What is a universal joint?—*A.* It is a device for connecting two shafts which are slightly out of alinement, and to transmit power through these angles.

*Q.* What is a slip joint?—*A.* A sliding or telescopic joint which is splined and permits variations in the length of the drive shaft. It is used to compensate for the variations in distance between transmission and rear axle due to the action of the springs.

*Q.* What is the purpose of the differential?—*A.* It permits one axle shaft connected to it to rotate slower, faster, or remain stationary in reference to the other axle shaft. Such a device is necessary to compensate for the difference in speed of the rear wheels when going around curves.

*Q.* What are the principal types of differentials used?—*A.* The bevel gear, spur gear, and worm gear differentials.

*Q.* Explain the principle embodied in the design of the bevel gear differential.—*A.* The differential case is attached to and driven by the ring gear. Four small bevel gears are mounted inside the differential case on a spider, the latter being supported by the case. The four gears are in mesh with a bevel gear on each side to which the axle is attached. On a straight road with equal traction the motion of the

ring gear is transmitted to the differential case; the spider gears remain stationary and cause the gears attached to the axle shafts to rotate in unison with the case. If one axle is retarded or stopped, as in rounding a curve, the gear attached to that axle is moving slowly or is stationary. The differential case being in motion turns the spider. The spider gears roll on the gear attached to the retarded or stationary axle, while the gear attached to the other axle is rotated at a higher speed. If one wheel stops, the other one will turn twice as fast as it did before the other wheel stopped.

*Q.* How is the power transmitted to the ring gear?—*A.* From the propeller shaft to a piston shaft to the pinion gear to the ring gear.

*Q.* Is the same principle included in the spur-gear differential?—*A.* Yes, it differs from the bevel gear only in construction.

*Q.* Explain the double-reduction-drive differential.—*A.* The only difference is that the first reduction is from the bevel-ring gear shaft to a small spur gear to a large spur gear connected to the differential case.

**11. Axles and wheels.**—*Q.* How many types of axles are in use?—*A.* There are two general classes, the dead and live axle.

*Q.* To what stresses are the semi-floating, three-quarter, and full-floating types of live axles subject? *A.*—

(1) The semi-floating axle is subject to the following stresses:

(a) Torsional stresses, due to the driving torque and braking torque.

(b) Bending stresses due to the weight resting on the axle.

(c) Bending stresses resulting from transverse loads on the wheels due to centrifugal force when turning corners at high speed.

(2) The three-quarter floating axle is subject to torsional stresses and bending stresses due to the load on the axle.

(3) The full-floating axle is subject to torsional stresses only.

*Q.* Wherein do the live and dead axle differ?—*A.* The dead axle is stationary, while the live axle revolves and delivers power to the wheels.

*Q.* What type wheels are used on motor vehicles? *A.*—

(1) Wood wheels with either wood or metal rims (artillery type).

(2) Wire wheels with metal hubs and rims and wire spokes.

(3) All-metal spoke wheels and all-metal disk wheels.

*Q.* What are the advantages of dual wheels?—*A.* They give greater carrying capacity, longer tire life, increased road contact, with consequent better traction, while the tires can be smaller in diameter, giving a lower center of gravity to the vehicle.

**12. Brakes.**—*Q.* What type brakes are used on motor vehicles?—*A.* Ordinarily two separate brakes are mounted on a vehicle, a service or foot brake and an emergency or hand brake.

*Q.* How are brakes operated?—*A.* Mechanical, hydraulic, or air operated. A vacuum booster may be used to work in conjunction with the mechanical or hydraulic brake.

*Q.* What is the advantage of the vacuum booster brake?—*A.* It lessens the brake pedal pressure necessary for brake application.

*Q.* Explain the operation of the vacuum booster.—*A.* A power cylinder is mounted so that the piston in the cylinder can be connected to the brake pedal. The cylinder is connected to the intake manifold by means of a copper tube. When the brake pedal is pressed partly down, a valve is opened to the intake pipe, and the suction from the intake manifold causes the piston to move and applies the brakes through the linkage to the brake pedal. When the brake pedal pressure is released, the inlet valve is closed, a valve to the atmosphere is opened, and a spring forces the piston back, releasing the brakes.

*Q.* What advantage is gained by mounting the brake on the transmission?—*A.* The braking effect is transmitted through the differential, drive shaft, and axle shafts, increasing the braking power.

**13. Steering gear.**—*Q.* Describe briefly the construction of a typical steering gear.—*A.* The steering wheel is keyed to a shaft supported by the steering column. The shaft terminates in a worm; the worm engages in a worm gear the shaft of which carries the steering lever arm. The steering lever arm is connected by the drag link to one of the steering knuckles. A tie rod connects the two steering knuckles.

*Q.* Explain the mounting of the front axle and wheels.—*A.* The front axle is fastened to the frame by means of leaf springs which are secured to the frame by shackles and shackle bolts. The axle is fastened to the spring by bolts. The wheels are mounted on spindles; the spindle is fastened to the end of the axle with a kingpin which allows the spindle to turn.

*Q.* Why are the steering arms curved toward the center of the vehicle instead of being straight?—*A.* Because in turning a curve the path of the outside wheel is an arc of a larger circle than the path of the inner wheel. Therefore, the outside wheel must be inclined at a lesser angle than the inside wheel. The angularity of the steering arms provides for this difference in inclination of the wheel.

*Q.* What is meant by toe-in (gather) of the front wheels?—*A.* It means the front wheels are so alined that the foremost edges are closer together than the rear edges. Since cambered wheels, like segments of a cone, have a tendency to roll outward in a circle, gathering the wheels in at the front is necessary to compensate for this tendency.

**Q.** What is meant by caster?—**A.** Caster is the angle of backward inclination between the steering knuckle bolts and the vertical, and its purpose is to stabilize steering.

**Q.** What is meant by camber?—**A.** Camber is the outward tilt of the front wheels at the top and results in the wheels coming more nearly under the load. The purpose of camber is to support the greater part of the car weight on the inner wheel bearings, to reduce side thrust on the steering knuckle bolts, to compensate for looseness and wear in the steering knuckle and wheel bearings, and to bring the point of pivot near the road for center point steering.

**Q.** What is meant by irreversible steering gear?—**A.** A steering gear in which turning motions can be transmitted to the steering knuckles by turning the steering wheel, but motions cannot be transmitted from the front wheels to the steering wheel.

**Q.** How is this accomplished?—**A.** By the use of a worm in the steering gear. A worm is capable of turning a gear, but the motion cannot readily be transmitted from a gear to a worm.

## SECTION II

### INSPECTION AND MAINTENANCE OF MOTOR VEHICLES

|                              | Paragraph |
|------------------------------|-----------|
| Power plant.....             | 14        |
| Carburetion .....            | 15        |
| Battery ignition.....        | 16        |
| Magneto ignition.....        | 17        |
| Battery .....                | 18        |
| Clutch and transmission..... | 19        |
| Wheels and brakes.....       | 20        |
| Cooling system .....         | 21        |
| Steering mechanisms.....     | 22        |
| Governors.....               | 23        |

**14. Power plant.—Q.** How are the causes of engine troubles determined?—**A.** Since nearly all of the operating parts of the engine are inclosed and inaccessible, the cause of engine trouble must usually be deduced by a system of elimination.

**Q.** How can engine troubles be classed?—**A.** They can be classed as—

- (1) Mechanical troubles.
- (2) Fuel feed and carburetion troubles.
- (3) Ignition troubles.

**Q.** What conditions are necessary for an engine to start?—**A.** If the following conditions exist, the engine should run :

(1) Engine turns freely without any indication of mechanical troubles and has compression.

(2) Gasoline reaches the cylinder, the cylinders being neither uncomfortably hot nor cold to the hand, the throttle being one-fourth open, and the intake clear and tight.

(3) There is a spark at the right time at the right place.

*Q.* In general, how are mechanical troubles remedied? *A.*—

(1) By disassembling such parts of the engine as necessary to get at the defective parts.

(2) By replacing broken or worn parts.

(3) By regrinding or replacing valves.

(4) By refitting or tightening loose bearings.

(5) By removing carbon.

*Q.* How should a bearing be refitted?—*A.* So that it is in contact with the shaft at all points.

*Q.* What inspection should be made when an engine is disassembled?—*A.* Inspect all parts for defects and make a list of all parts needed.

*Q.* Why is a small clearance left at the end of the valve stem?—*A.* To allow for expansion and to insure that the valve is closed.

*Q.* What is the result if a valve does not close all the way?—*A.* There is a loss of compression. If it is an exhaust valve, the seat will burn and warp, due to the hot escaping gases.

*Q.* What is meant by valve grinding?—*A.* The grinding of the valve face and seat to a gastight fit, with valve-grinding compound.

*Q.* What is meant by a valve seat insert?—*A.* A very hard steel ring inserted in the valve port to form the valve seat.

*Q.* Is it possible to reseat valve seat inserts?—*A.* Only by the aid of special valve seat insert grinding stones.

*Q.* How often should they be resealed?—*A.* About every 50,000 to 65,000 miles. In some cases, they last the life of the vehicle.

*Q.* How is the compression of an engine tested?—*A.* Remove all spark plugs, open the throttle wide open, insert a compression gage in No. 1 cylinder, and crank the engine either by hand or by battery about six revolutions. Take the reading of meter on a gage. If the reading is low, the compression is bad. Check each cylinder in the same manner. Compression in all cylinders should not vary more than 5 pounds. If no gage is available, leave all spark plugs in place. Crank the engine by hand. Each cylinder should have about the same resistance when cranked against compression. A cylinder with good compression will show a springy resistance and the engine can be rocked against compression.

*Q.* How much gap clearance should piston rings have?—*A.* The top ring should have 0.003 of an inch per inch of piston diameter. The other rings should have 0.002 of an inch per inch of piston diameter.

*Q.* How are piston rings fitted?—*A.* Place the rings in the cylinder, turn the piston upside down, and push the ring down about 1 inch from the top of the cylinder. Check the gap with a feeler gage.

**15. Carburetion.**—*Q.* How is a carburetor adjusted?—*A.* Start the engine and allow it to warm up. Retard the spark, close the throttle, and set the throttle-adjusting screw so the engine will idle. Adjust the idle-adjusting screw to where the engine runs smoothly without rolling or missing. Adjust the high-speed adjusting screw (if the carburetor has one) to where the engine will spit back into the carburetor. It should spit back once and no more.

*Q.* Name the most frequent carburetor troubles.—*A.* Strainers stopped up, jets stopped up, float too low or too high, and float punctured.

**16. Battery ignition.**—*Q.* Name the most frequent causes of ignition troubles in a battery ignition system. *A.*—

(1) *Spark plugs.*—Dirty plugs, broken porcelain insulation, improper connections, or improper spark gap.

(2) *Cables.*—Defective insulation, not connected, connected to wrong spark plug or distributor contact, or broken wire inside of insulation.

(3) *Breaker points.*—Do not close, do not open at proper time, do not open enough, points pitted, or dirt between points.

(4) *Condenser.*—Short-circuited.

(5) *Battery.*—Run down, not connected, short-circuited, or grounded.

*Q.* How is the ignition timed on the battery ignition system?—*A.* The piston of No. 1 cylinder is set at top dead center at the end of the compression stroke. The flywheel is usually marked to indicate this position by ignition timing marks, such as IGN 1-6 or D. C. The distributor-housing clamping screw is loosened and the distributor cap is removed. The housing must be turned to where the rotor finger is in contact with No. 1 terminal and the breaker points are just beginning to open; the clamping screw should then be tightened.

**17. Magneto ignition.**—*Q.* Name the most frequent causes of ignition troubles in a magneto ignition system.—*A.* Improper timing, short circuit, burnt armature, defective contact points or brushes, or weak magnets.

(1) *Coil.*—Short-circuited, or broken insulation.

(2) *Distributor*.—Broken contacts or brushes, water or dirt in distributor, distributor (or rotor finger) removed or broken, or distributor head cracked.

(3) *Switch*.—Open circuit, short circuit, or improperly connected.

*Q.* How can the timing of the spark be regulated to vary with engine speed?—*A.* By automatic spark control or by manual spark control.

*Q.* How are ignition troubles traced?—*A.* By asking one's self the following questions and finding the answers: Test for a spark at the spark plug. If there is no spark, is the switch turned on? Is the battery all right? Are any wires disconnected or terminals corroded? Are wires connected correctly? Are any wires broken? Do the breaker points open and close properly? Is there a spark at the spark plug at the proper time? Are spark plug gaps of the proper width? Are porcelains and electrodes clean and unbroken? Is there too much gasoline in the cylinders so the spark plugs are fouled?

*Q.* If, when the breaker points open, there is an excessive spark or arc at the point of opening, what is the trouble?—*A.* A disconnected or defective condenser.

**18. Battery.**—*Q.* When a new battery is received, what is the first thing to do?—*A.* Unpack the battery, keeping the packing case right side up to avoid spilling the battery solution. Examine the battery carefully to see if there is any indication of injury during transit. Determine whether the battery has been shipped charged or unfilled.

*Q.* What care is necessary when installing a battery on a car?—*A.* When connecting the battery to the battery cables, be sure they are connected properly and are tight, and the terminals are greased with vaseline or some lubrication grease.

*Q.* How can one determine whether the battery is connected properly?—*A.* Look up the diagram in the service book, or turn the lights on and note the reading of the ammeter. If the engine is not running, the ammeter should indicate discharge if the battery is properly connected.

*Q.* What attention does the battery require in service?—*A.* It requires very little attention, but that little is absolutely necessary and vital. Add nothing but pure distilled water to replace that lost by evaporation. Do this often enough to keep the plates covered about  $\frac{1}{2}$  inch. In freezing weather do not add water until just before the battery is to be used or recharged. Keep the connections tight and covered with vaseline. Keep the filling plugs tight and battery dry, clean, and clamped down tightly in the carrier. Take hydrometer readings and check water every 2 weeks in the summer. If the vehicle is put in storage or held for repairs, the battery should be removed, charged, and put into proper storage.

**Q.** How should corroded battery terminals be cleaned?—**A.** By scrubbing thoroughly with ammonia, or a solution of baking soda and water.

**Q.** What should be the specific gravity of—

- (1) A fully charged battery?
- (2) A half-charged battery?
- (3) A fully discharged battery?

**A.** In normal temperatures they should be, respectively—

- (1) 1.300.
- (2) 1.250.
- (3) 1.130 or lower.

**Q.** At what temperature will the following freeze:

- (1) A fully charged battery?
- (2) A fully discharged battery?

**A.** They will freeze at—

- (1) Approximately 96° F. below zero.
- (2) About 32° F. above zero.

**Q.** Name some of the common lighting faults.—**A.** Lamps in circuit will not burn because of—

- (1) Being burned out.
- (2) Blown fuse.
- (3) Open circuit.
- (4) Poor ground in single wire system.
- (5) Battery discharged.
- (6) Loose connections.

**Q.** What will cause the lights to burn out?—**A.** Loose battery connection, reverse current relay points sticking, or lamp bulbs of the wrong voltage.

**Q.** If lights dim when engine is cranked with the electric starter, what is the trouble?—**A.** Weak battery or loose battery connections.

**Q.** If the generator does not charge the battery, what may be the trouble? **A.**—

(1) Generator not building up, usually due to dirty commutator or worn brushes.

- (2) Corroded or loose battery terminals.
- (3) Defective battery.
- (4) Ammeter burned out.
- (5) Defective reverse current relay.

**Q.** If the batteries do not stay charged, what may be the fault? **A.**—

- (1) Charging rate too low.
- (2) Ground in car wiring.
- (3) Reverse current relay not operating properly.

**Q.** In case of trouble with the electric starter, what should be done?

**A.**—

- (1) See that the battery is charged.
- (2) See that there are no short circuits.
- (3) See that the battery terminals are not loose, rusty, or corroded.
- (4) Examine the starting switch for proper connections and operation.
- (5) See that the brushes are properly seated on motor commutator.

**19. Clutch and transmission.**—**Q.** Name the most usual clutch troubles.—**A.** Slipping, grabbing, and chattering.

**Q.** What are the causes?—**A.**

- (1) Slipping is usually caused by friction material of the disk being worn, the clutch springs failing to exert sufficient pressure, or from allowing the foot to rest on the clutch pedal while driving.
- (2) Grabbing is caused by oil on the clutch plates, spring with too great a capacity, or faulty lining.
- (3) Chattering is caused by the clutch shaft and driving members being out of alinement with the driven member.

**Q.** To what are most clutch troubles due?—**A.** They are due to the clutch throw-out bearing becoming worn.

**Q.** Name the most usual transmission troubles and their causes.  
**A.**—

- (1) Difficulty in shifting gears, usually caused by broken parts, by oil which has become gummy, by insufficient or too much oil, or by the gear shift lever connections being out of order.
- (2) Transmission gear stripped, caused by changing from a forward to a reverse gear when the vehicle is in motion.

**Q.** What troubles may develop in the drive?—**A.** Broken drive shaft or universal joints. The drive shaft may break or be bent by—

- (1) Contact with road obstructions.
- (2) Excessive differential gear clearance.
- (3) Racing the engine and jerking the vehicle by suddenly applying the power to the axle shafts.

**20. Wheels and brakes.**—**Q.** What are the usual causes of troubles which are experienced with wheel bearings?—**A.** Improper adjustments and insufficient lubrication.

**Q.** How should wheel bearings be adjusted?—**A.** The bearing adjusting nuts should be tight enough to prevent end play, but not so tight as to prevent the wheel from turning freely.

**Q.** What are the results of insufficient lubrication of the wheel bearings?—**A.** Heat of the bearings, rapid wear, and breaking of the bearing balls or rollers.

*Q.* What troubles are experienced with brakes?—*A.* Worn-out brake lining, unequal adjustment of the brake bands or shoes, scored drums, brake lining stripping from the shoes and rolling up at the ends, oil leaks in the lines, brake, or master cylinders in the case of hydraulic brakes, unequal linkage and rod adjustments, and oil on brake lining.

*Q.* What precautions must be taken with brakes?—*A.* Brakes must be tested and inspected frequently, worn lining must be replaced, and the brake bands kept in proper adjustment.

*Q.* How can the wear of the brakes be reduced?—*A.* By using the engine to produce braking effect. In descending long, steep grades, the vehicle should be run in second or low gear to help brake the vehicle.

*Q.* When does the greatest braking effect occur?—*A.* Just before the wheels begin to slide.

*Q.* What troubles are experienced with the steering mechanism?—*A.* Front wheels out of alinement, broken parts, and parts becoming worn and loose.

*Q.* What is the most common trouble?—*A.* Wheels out of alinement, caused by wear, or by hitting curves or obstructions on rough roads and detours.

*Q.* What care should be taken of tires?—*A.* Keep sufficient air pressure in them, keep rims tight, and avoid running over glass or sharp stones as much as possible. Do not run on a flat tire. Never let a tire sit in oil or gasoline, as it will rot the rubber.

**21. Cooling system.**—*Q.* Should a water-cooled engine be run without water in the cooling system? Why?—*A.* No. It will cause the engine to run hot, and the metal will expand and cause the pistons and rings to seize the cylinder walls due to the burning of oil from the cylinder walls.

*Q.* If the engine is overheated, how should water be added?—*A.* The engine should be allowed to cool before water is added and then water should be added very slowly with the engine running.

*Q.* How should the radiator and water jackets be protected in cold weather?—*A.* A close check should be kept on the antifreeze solution. Unless sufficient antifreeze solution is used, the radiator and water jackets should be completely drained when the vehicle is not in use, and a "drained" sign should be hung on the radiator. Sometimes it will be necessary to protect the lower front half of the radiator with tin, cardboard, or canvas during operation.

**22. Steering mechanisms.**—*Q.* How are kingpins (steering knuckle pivots) generally set with respect to the plane of the wheel?—

A. They are generally set at an angle with the plane of the wheel. This angle is referred to as the kingpin (or pivot) inclination angle.

Q. What is the caster angle?—A. It is the slight backward tilt of the front axle and the kingpins (or pivots); the top of the front axle having been rotated backward through that angle.

Q. What is camber?—A. It is the angle (or distance) that the wheel leans outward at the top.

Q. Are the front wheels closer together at the rear of the wheels or at the front of the wheels?—A. They are closer together at the front.

Q. What is this difference (or angle) called?—A. It is called toe-in.

Q. How is it set?—A. By means of the tie rod between the steering knuckles.

Q. What is this series of angles and adjustments called?—A. Front wheel geometry.

Q. What should be the values of these angles for a particular vehicle?—A. As specified by the manufacturer.

Q. What type of lubricant is required for steering gears? Why?—A. A light, pressure-resistant lubricant is required because the slow, sliding motion of the surfaces in contact tends to scrape off any film of lubricant and cause metal-to-metal contact.

Q. What is the usual method of lubricating the working parts?—A. The inclosed, oiltight steering-gear housing is filled with steering-gear lubricant so that the teeth and spirals are coated at all times.

**23. Governors.**—Q. What is the purpose of governors?—A. To protect the vehicle engine and to insure economical, accident-free operation.

Q. How are governors tested?—A. By giving the vehicle a road test.

Q. How much adjustment is possible with the common types of governor?—A. Governors are designed to give speed adjustments over about a 10-mile-per-hour range. If wider adjustments are attempted, erratic operation may result because of broken springs or cams in the governor.

Q. How are drivers prevented from tampering with the governor?—A. The governor is sealed. Frequent inspections are made to see that the governor has not been tampered with or damaged.

### SECTION III

## SHOP PRACTICES; SUPERVISION AND INSTRUCTION OF MECHANICS

|   | Paragraph |
|---|-----------|
| Shop practices.....                           | 24        |
| Precautions as to fire in garages.....        | 25        |
| Supervision and instruction of mechanics..... | 26        |

**24. Shop practices.**—*Q.* What are some precautions to be taken in disassembling an automobile? *A.*—

- (1) Plan the quickest and easiest way to do the job.
- (2) Drain oil, water, and gasoline.
- (3) Plan to protect delicate parts and machined surfaces.
- (4) Plan how to save gaskets from injury.
- (5) Tag all electric wires.
- (6) Look for any screws, bolts, or nuts which may allow any part to drop or otherwise be damaged before removing.
- (7) Mark with a prick punch pieces which may be reassembled wrong.
- (8) Provide containers for all parts.
- (9) Secure proper tools and use them according to instructions.
- (10) Inspect parts as taken down, so replacements can be secured promptly.

*Q.* How is a tight nut removed?—*A.* Use as hard a direct pressure as can be applied safely with a wrench. Try jerking wrench first one way and then the other. Apply kerosene or penetrating oil, allowing time for it to soak in between the threads. If all of the above fail, split the nut with a cold chisel, backing it up with a heavy bar or hammer.

*Q.* Give, in brief, several points to be observed when engaged in overhauling.—*A.* Every part removed must be replaced *in exactly the same place occupied before overhaul.* To do this, all parts should be either tagged or marked with a steel stencil so that they may be easily identified. Always use the proper tools.

*Q.* Mention some important things to avoid in the repair and maintenance of automotive vehicles. *A.*—

- (1) Don't use adjustable wrenches for hammers.
- (2) Don't use screw drivers as cold chisels.
- (3) Don't use pliers on nuts or bolt heads.
- (4) Don't use stillson wrenches on nuts or bolt heads.
- (5) Don't attempt to loosen nuts with a hammer and cold chisel.
- (6) Don't use screw drivers for prying.
- (7) Don't use a wrench on a nut or bolt that it does not fit.
- (8) Don't use a file without a handle.
- (9) Don't strike polished parts of machinery with a steel hammer.
- (10) Don't use a hammer on cast steel or iron.
- (11) Don't use excessive force. If a part does not come off easily, investigate before using force.
- (12) Don't use a hammer to separate parts which should be pulled or pressed apart.
- (13) Don't neglect or mislay tools.

(14) Don't pound on the end of a shaft with a bare hammer. Use a babbit hammer or a piece of wood or brass over the end of the shaft.

(15) Don't smear oil or grease on seats or paint. Remove seats and cover fenders.

(16) Don't leave a vehicle standing in a pool of grease.

*Q.* How should oils and grease be kept and issued? Who should lubricate the vehicle?—*A.* All lubricants should be issued by one man. Due to the specialized lubrication requirements of modern vehicles, it is considered the best practice to have the actual lubrication of vehicles performed by a trained man, rather than by the individual drivers.

*Q.* How are supplies, spare parts, and special tools kept and issued?—*A.* Every repair shop, no matter how small, should have a stock room with one man responsible for the issue of supplies and tools.

*Q.* How are open-end wrenches classed as to size?—*A.* U. S. S. wrenches are numbered from 21 to 45 and the SAE type are marked as to size.

*Q.* Why are two systems necessary?—*A.* Because of the two kinds of bolts; for example, a  $\frac{1}{2}$ -inch U. S. S. nut is seven-eighths of an inch on the outside while a  $\frac{1}{2}$ -inch SAE nut is only three-fourths of an inch. SAE is the common type.

*Q.* What two kinds of threads are there on bolts?—*A.* U. S. S. and SAE. They differ in the pitch or number of threads to the inch.

**25. Precautions as to fire in garages.**—*Q.* Name some of the precautions that should be taken to prevent fires in garages. *A.*—

(1) No smoking should be allowed where there are gasoline fumes.

(2) Gasoline cleaning mixtures must not be used.

(3) Covered metal containers should be provided for discarded oily waste, and these containers should be emptied every day at closing time.

(4) Soiled overalls and fatigue clothes should be kept in metal lockers.

*Q.* What care should be taken when welding or repairing gasoline tanks?—*A.* After the gasoline is drained off, the tank should be washed out several times and then live steam run through to rid the tank of all liquid and vapor.

*Q.* What inspection should be made of portable light cords?—*A.* They should be inspected for breaks and short circuits.

*Q.* Should gasoline be handled or used inside a building?—*A.* Only when absolutely necessary, in which case the windows should be open.

*Q.* Should water be thrown on burning gasoline?—*A.* No. It only spreads the fire.

*Q.* What means should be available to extinguish fires? *A.*—

(1) Fire extinguishers should be hung in convenient places about the shop and tested frequently.

(2) Pails of sand should be provided.

*Q.* Should vehicles that are left in a garage be locked?—*A.* No. They should be unlocked so they can be run out easily in case of fire. Keys should be in the vehicles or in some convenient nearby spot.

**26. Supervision and instruction of mechanics.**—*Q.* What texts are available for the basic training of mechanics?—*A.* Technical Manuals of the TM 10- series.

*Q.* Where may the mechanic find instructions for performing jobs assigned to him?—*A.* In the instruction manuals of the vehicles concerned.

*Q.* What, briefly, are the duties of the transportation sergeant in the supervision and instruction of mechanics? *A.*—

(1) He assigns the mechanics to jobs according to their ability.

(2) He checks each job step by step.

(3) In case a mechanic gets into difficulty, he shows such mechanic how to do the job.

(4) He acts as the motor officer's executive.

## SECTION IV

### LOADS AND THEIR PROPER DISTRIBUTION

|                             |    |
|-----------------------------|----|
| Paragraph                   |    |
| Loads and distribution----- | 27 |

**27. Loads and distribution.**—*Q.* What information should be obtained at the time an order for transportation is taken?—*A.* Orders should never be taken for transportation without learning the weight of the load it is desired to transport, the points between which it is desired to transport it, and the nature of the load, in order that suitable vehicles may be furnished for the work.

*Q.* What are the duties of the convoy commander with respect to the cargo?—*A.* Loading and unloading in the field will often require work under adverse conditions. Whatever the conditions are, it is the duty of the convoy commander to deliver the freight in the best possible condition; in the least possible time, and with due regard to the condition of his command; and, when possible, to park the trucks so as to minimize the work of unloading and handling the cargoes.

**Q.** What is the effect of poor loading?—**A.** A poorly loaded vehicle not only reduces the capacity of that truck, but endangers the safety of the entire convoy.

**Q.** What may be the effect of a swaying load?—**A.** A poorly loaded truck with a swaying load is always in danger of overturning.

**Q.** Give some general rules for loading. **A.**—

(1) Heavy goods should be placed at the bottom, near the rear of the truck and as close to the rear axle as possible.

(2) Loads should be distributed equally on both sides of the truck. Every load should be securely lashed and covered.

(3) Lumber should be loaded with heavy pieces on the bottom, grading up to lighter on top to a height of about twice the body; 2-inch by 4-inch uprights should be placed every 3 feet along the sides.

(4) Baled goods, sacks, and similar loads should be piled evenly over the body and, when they extend above the sides of the body, should be pyramided until there is a single row parallel to the body length.

(5) In mixed loads, common sense is the only rule that can be laid down.

(6) Never overload a vehicle.

**Q.** What precautions should be taken when loading ammunition? **A.**—

(1) Do not load fuzes or detonators with explosives.

(2) Cover the iron strips of the truck body with wood or its equivalent.

(3) Cover the load with paulin to protect it from weather or possible sparks.

(4) Do not unload with engine running.

(5) Brace the load if the truck body is not full.

**Q.** What may result if a load is placed entirely on one side of a truck?—**A.** Skidding into a ditch if roads are at all wet, or the breaking of a spring.

**Q.** What may result if a load is placed entirely on the rear of the truck body?—**A.** On dirt roads there are often bog holes in which the rear wheels will sink if load is entirely over rear axle or behind.

**Q.** How should a small but heavy object be loaded on a truck?—**A.** Two pieces of timber about 4 by 4 inches should be placed on each side of the body, running its entire length. Two other pieces of timber of the same size should be placed across the first two, near the center of the truck body and near enough together to support the object to be loaded. This will give a well-distributed load, the strain being divided among all the members.

*Q.* Where can the data giving the loading capacity of a truck be found?—*A.* On a plate on the dash.

*Q.* What will be the result of overloading a truck?—*A.* Excessive wear and strain on all parts, including the engine; springs will become weak and allow the load to rest on the axles.

*Q.* What equipment for lashing loads should be on each truck?—*A.* Two 60-foot lengths of rope and the lash hooks or rings through which the lines are passed.

*Q.* How can the motor sergeant make a quick check on overloading?—*A.* By noting the set of the springs.

*Q.* What determines the loads and distribution of loads for a motorized regiment in the field?—*A.* The loading table which is based upon the Tables of Allowances of the regiment. Under such circumstances there will be no cargo space for items not on the Tables of Allowances.

## SECTION V

### TRAINING OF DRIVERS

Training of drivers..... Paragraph 28

**28. Training of drivers.**—*Q.* What, in general terms, determines the mobility and dependability of the motor vehicle fleet?—*A.* The manner in which the individual drivers perform their duties.

*Q.* What should be the preliminary step to the training of drivers to operate motor vehicles?—*A.* The preparation of a training schedule to include a systematic and progressive course of instruction.

*Q.* What relative time value should be given practical instruction and classroom work in the training schedule?—*A.* Training schedules should include a maximum of practical instruction and a minimum of classroom work.

*Q.* What should be the qualifications of an individual selected for training as a motor vehicle driver?—*A.* He should be dependable, alert, sober, steady, and ambitious, and should have good judgment and mechanical sense. He should react quickly and properly in given test situations. He should be able to differentiate promptly between red, green, and amber lights.

*Q.* What is the principal object in the training of motor vehicle drivers?—*A.* To turn out drivers who are capable of good performance under all reasonable operating conditions.

*Q.* What instruction should be given to cover subjects on organization and safety?—*A.* Instruction regarding—

(1) Motor transport personnel and general duties.

(2) The organization of the motor park and the duties of the driver in connection therewith.

(3) Fire prevention and fire fighting to include precautions against fire, proper methods of fighting fire, location of fire-fighting equipment, and the method of reporting fire.

(4) Accident prevention to include precautions against accidents, carbon monoxide poisoning, and whom to call to get assistance.

Q. What motor vehicle controls should be explained and demonstrated?—A. Carburetor choke control, carburetor throttle control (to include accelerator), ignition switch, spark control, transmission gear shift lever, subtransmission gear shift lever, clutch pedal, steering wheel, and brakes (hand and foot).

Q. What procedure would one follow in this explanation and demonstration? A.—

(1) Securely block up the motor vehicle with all wheels off the ground.

(2) Have the candidate familiarize himself with the location and manipulation of the clutch pedal, the transmission gear shift lever, the brake lever, and brake pedal.

(3) Start and warm up the engine.

(4) Demonstrate the operation of the accelerator; coordinated movements of the accelerator, clutch pedal, and transmission gear shift lever; gear shifting, to include reverse; operation of the brake controls; manipulation of the steering wheel; and the use of the engine as a brake.

(5) Upon completion of the demonstration, have the candidate assume the correct position in the driver's seat and practice manipulating the controls until he becomes reasonably proficient. Exercise careful supervision to insure correct performance.

Q. Explain the correct position a driver should assume when in the driver's seat.—A. He should sit erect, without stiffness, squarely behind the steering wheel; head erect, eyes looking to the front; hands on opposite sides of the steering wheel, on a horizontal line generally through the center of the wheel, grasping the steering wheel rim firmly but without tenseness; both feet flat on the floor boards except when actually manipulating the accelerator, the clutch and brake pedals, or the starter switch.

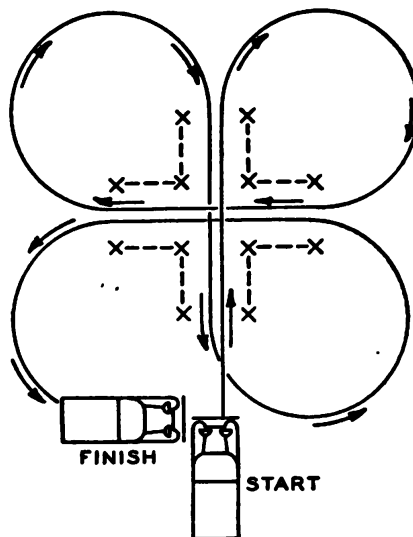
Q. What aids to motor vehicle control should be explained and demonstrated?—A. Light switches, horn button, rear-view mirror, windshield wiper, speedometer, and tachometer.

Q. What information should be given regarding the instrument-board gages?—A. The purpose of each gage should be explained, its

normal reading given, and the driver instructed as to what he should do when an abnormal reading is observed.

*Q.* Why is careful instruction and painstaking supervision necessary during the driving instruction period?—*A.* To insure that the driver learns the correct performance of his duties and forms the proper habits.

*Q.* Name the subjects that should be covered during the driving instruction period.—*A.* Gear shifting and use of clutch, use of transmissions, use of brakes, turning, backing, parking, starting engine under unusual operating conditions, signals, road rules and traffic regulations, chains and traction devices, marching, difficult and night driving, loads and loading, and map reading.



(The figure should be symmetrical, with the stakes placed to allow an over-all side clearance of approximately 18 inches.)

FIGURE 7.—Reverse turning course.

*Q.* How should a driver be instructed in gear shifting and use of clutch?—*A.* Conduct the instruction on a large, open field where steering is of secondary importance. Explain procedure and demonstrate application. Permit the candidate to drive at will with the transmission in the lower gear ratios until he is reasonably familiar with the operation and control of his vehicle. After he has become reasonably proficient in shifting from lower to higher gears, instruct him in the procedure of double clutching.

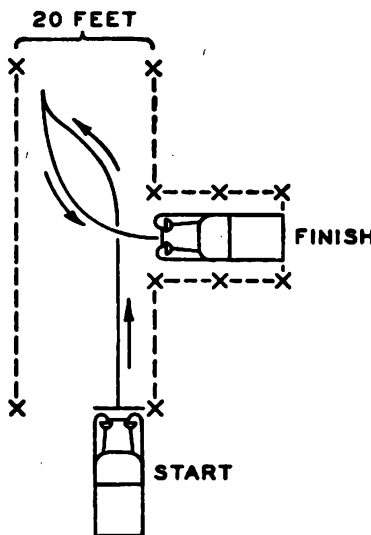
*Q.* How would one instruct drivers in turning, backing, and parking?—*A.* By the use of stake driving courses (see figs. 7, 8, and 9).

*Q.* In what kinds of preventive maintenance would one instruct the drivers?—*A.* Inspection, lubrication, tightening, servicing, and

cleaning of motor vehicles, the avoidance of vehicle abuse, and the performance of emergency adjustments and repairs.

*Q.* In what routine inspections should the driver be instructed?—*A.* Inspection before operation, both before starting engine and after starting engine; inspection during operation; inspection at the halt; and inspection after operation.

*Q.* What forms of vehicle abuse should be the subject of special instruction?—*A.* Improper use of controls, particularly gear shift, clutch, brakes, and choke; racing engine, especially when cold; over-speeding, particularly over rough roads and across country; improper lubrication; deferred maintenance, including lack of proper servicing and adjustments; lack of systematic inspection and follow-up; over-loading and improper loading.



(The figure should be symmetrical, with the stakes placed to allow an over-all side clearance of approximately 18 inches.)

FIGURE 8.—Backing course.

*Q.* Name the driver's reports which are generally applicable to all arms and services operating and maintaining motor vehicles, the preparation and use of which would be covered in your instruction.—*A.* Standard Form No. 26 (Driver's Report—Accident, Motor Transportation); W. D., Q. M. C. Form No. 237 (Driver's Trip Ticket and Performance Record).

*Q.* To whom will motor vehicle operators' permits be issued?—*A.* Only to individuals who have satisfactorily passed an examination conducted by a qualified commissioned officer.

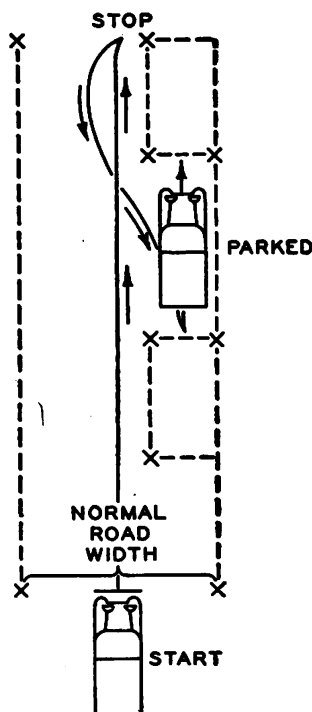
*Q.* What subjects does this examination cover? *A.*—

(1) *Mechanical.*—Nomenclature and functions of major units of the motor vehicle.

(2) *Operation*.—Actual driving of the vehicle, involving use of controls, reversing, and parking under usual conditions of traffic and terrain; traffic regulations, road procedure, safety precautions, speed limits, and vehicle abuse.

(3) *Maintenance*.—First echelon (vehicle operator's) maintenance.

*Q.* What should the possession of a motor vehicle operator's permit guarantee?—*A.* That the individual is a safe driver.



(Stakes should be placed so that when parked the vehicle will have an over-all longitudinal clearance of approximately 10 feet and a lateral clearance of approximately 3 feet.)

FIGURE 9.—Parking course.

## SECTION VI

### CONVOY DISCIPLINE, RULES OF THE ROAD, AND ROAD INSPECTIONS

|  | Paragraph |
|--|-----------|
| Rules of the road.....                 | 29        |
| Convoy regulations and discipline..... | 30        |
| Speed laws and regulations.....        | 31        |
| Parking.....                           | 32        |
| Road inspections.....                  | 33        |

**29. Rules of the road.**—*Q.* What are the general rules of the road with regard to warning signals?—*A.* Appropriate warning signals will be given before changing direction, slowing down, or stopping.

*Q.* What are the rules with regard to passing traffic moving in the same direction? *A.*—

- (1) Never pass when going around a corner or a blind curve.
- (2) Never pass when going up or down hill unless safe passage is assured.
- (3) Never pass at street intersections or crossroads.
- (4) Never pass when the road is not wide enough to allow at least 2 feet between vehicles.

Q. What are the rules with regard to meeting and passing an on-coming vehicle? A.—

- (1) Pass on the right, giving at least half the road.
- (2) Slow down if operating conditions are hazardous.
- (3) Permit the vehicle having a clear road ahead to have the right-of-way.

Q. What is the rule with respect to speeds on dusty roads?—A. Speeds will be reduced on dusty roads.

Q. What are the rules as to night driving? A.—

- (1) When driving with lights, the vehicle will be kept well to the right and lights will be dimmed when meeting another vehicle.
- (2) When driving without lights, speeds will be reduced to accord with road conditions, degree of visibility, and skill of the drivers.

Q. What will be done at a railroad crossing?—A. Vehicles will be halted unless the crossing is guarded by military personnel or civilian watchmen.

Q. What will be done at road intersections?—A. Vehicles will be slowed down to a safe stopping speed at all road intersections not covered by traffic control personnel or traffic control devices.

Q. What are the rules as to halting? A.—

- (1) Vehicles will clear the roadway before being halted.
- (2) Vehicles will not be halted on bridges, in defiles, at points where the vision of other drivers is restricted, or in such manner as to block cross traffic or entering side traffic.

Q. Which has the right-of-way in each of the following cases:

- (1) Two vehicles approaching an intersection where there are no stop signs, traffic signals, or police officers?
- (2) Two vehicles, one approaching an intersection and one already in the intersection?
- (3) Two vehicles moving in the same direction at different speeds?
- (4) Motor vehicles and pedestrians at an intersection where there are no traffic signals or traffic officers?

A. The following have the right-of-way:

- (1) The vehicle on the right.
- (2) The vehicle which has already entered the intersection.
- (3) The faster-moving vehicle.
- (4) Pedestrians.

**30. Convoy regulations and discipline.**—*Q.* What is the purpose of a convoy?—*A.* The efficient transportation of troops and matériel by groups of motor vehicles.

*Q.* On what does its success depend? *A.*—

- (1) Condition of vehicles.
- (2) Training and discipline of personnel.
- (3) Available roads.
- (4) Climatic conditions.

*Q.* How many vehicles make a convoy?—*A.* Two or more vehicles operating together constitute a convoy.

*Q.* When a convoy consists of more than 10 vehicles, how is it divided?—*A.* If there are more than 10 vehicles, they should be divided into sections.

*Q.* Who rides on the first vehicle of each section?—*A.* The truck-master of that section.

*Q.* What operators are required for each vehicle and what are their duties?—*A.* Whenever possible, there will be on each vehicle a driver and an assistant driver. The driver will drive the vehicle, keeping the vehicle to the right-hand side of the road. He will follow, at safe distance, the vehicle ahead of him in the convoy. The assistant driver will watch for all signals and communicate them to the driver. He will pass on the necessary signals to the vehicle following and will relieve the driver occasionally on long trips.

*Q.* What are the proper distances between vehicles in a convoy?—*A.* In order to avoid excessive "accordion effect," no rigid distances between vehicles should be prescribed. However, minimum safe distances are prescribed, the distance in yards in closed formation being approximately twice the speedometer reading. In open formation, distances between vehicles should be increased.

*Q.* What is the easiest way for a large convoy to get through a city?—*A.* The convoy commander or advance agent should make arrangements for a police escort through a city.

*Q.* What should the first vehicle do when it becomes necessary to open or close the convoy?—*A.* When it is necessary to open the convoy, as when approaching a hill, the first vehicle should speed up so that those behind can take the proper distance. After the necessity for opening has been passed, the first vehicle must slow down in order to permit the following vehicles to close up to proper distance.

*Q.* What governs the speed of the first truck?—*A.* The speed of the last vehicle. The speed of the first vehicle must be governed in

such a way that the last vehicle may keep its place at the proper distance and not fall behind.

*Q.* How is a convoy started?—*A.* All vehicles in a section should start at the same time. Vehicles should start at a slow speed so that they may take their proper distance in the section. A section should not start until the section commander has assured himself that all the vehicles are ready to start.

*Q.* Describe driver's arm signals. *A.*—

(1) *Turn right.*—Extend left arm outward at an angle of 45° above the horizontal.

(2) *Turn left.*—Extend left arm outward horizontally.

(3) *Slow or stop.*—Extend left arm outward at an angle of 45° below the horizontal.

(4) *Pass and keep going.*—Extend left arm horizontally and describe small circles toward the front with the hand.

*Q.* Describe the commands and signals commonly used in a motorized unit. *A.*—

(1) *Start engine.*—Simulate cranking.

(2) *Ready to start.*—Senior in truck stands on running board, faces leader, and extends arm vertically, fingers extended and joined, palm toward the leader.

(3) *Stop engine.*—Cross arms in front of body at the waist and then move them sharply to the side. Repeat several times.

(4) *Increase speed.*—Carry closed fist to the shoulder and rapidly thrust it vertically upward several times to the full extent of the arm.

(5) *Close up.*—Extend arms horizontally straight to the front, palms in. Move the hands together and then resume the first position. Repeat several times.

(6) *Open up.*—Extend arms horizontally straight to the front, palms out. Move the hands outward and then resume the first position. Repeat several times.

(7) *Danger.*—Use three long blasts of a whistle or automobile horn repeated several times or three equally spaced shots from a rifle or pistol. The person making the signal points in the direction of the impending danger. This signal is reserved for warning of air or mechanized attack or other immediate and grave danger. Other signals may be found in FM 25-10.

*Q.* How is a convoy stopped?—*A.* All vehicles should stop gradually, and pull well over to the right of the road. Care should be taken not to block streets or crossroads. A straight, open stretch of road, outside of towns, where water is available should be selected for such stops.

Q. Name some precautionary measures that should be taken while on the march. A.—

(1) At each halt, truckmasters, mechanics, and drivers should make a general inspection of vehicles at once.

(2) Upon arrival at any doubtful bridge, the convoy should be halted and the bridge inspected before allowing any vehicle to proceed.

(3) If, for any reason the convoy commander has occasion to leave his convoy, he should always appoint a commander to take his place, and should give definite and explicit instructions to his successor.

(4) Local speed and other regulations should always be observed.

(5) Unnecessary delays should be avoided; time once lost is most difficult to make up.

Q. What provisions are made for the care of disabled vehicles?—A. The last truck of the convoy should carry the tools, ropes, jacks, etc., which are necessary to effect simple road repairs. This vehicle should be under charge of the maintenance officer or an experienced mechanic who will act as file closer, and will have the assistant mechanics as near him as possible. His duties are to assist any disabled vehicle, and to make proper disposition of broken-down vehicles, subject to the orders of the commanding officer. The file closers will not leave any vehicle of the convoy without taking the proper measures either to repair the vehicle on the road, tow it along with the convoy, or make other proper disposition of it.

Q. What precautions should be taken at a crossroad where trucks are separated considerably or when crossing a railroad track?—A. A man from the leading vehicle should be detailed to give proper directions to the following vehicles at a crossroad, or to watch the track. He should get on the last vehicle that passes and take his regular place at the next stop.

Q. In cold weather, what precautions are taken against a delay in starting?—A. The drivers should be at their places in ample time to prepare the vehicles for the road, so that the convoy will start on time.

Q. What are the normal positions of—

- (1) The convoy commander?
- (2) The control car?
- (3) The maintenance vehicle?

A. The normal positions are:

- (1) At rear of convoy.
- (2) Leading the convoy.
- (3) Trailing the convoy.

Q. How is the normal day of a convoy divided? A.—

(1) Breakfast, police of camp, preparations for starting; 1 to 1½ hours.

- (2) Morning period on road, 5 hours.
- (3) Noon halt, 1 hour.
- (4) Afternoon period on road, 3 hours.
- (5) Servicing vehicles and supper, 1½ to 2 hours.

Q. Should departures ever be made from this division of time?—

A. No, except in extending the driving periods in an emergency. Driving a heavy truck at road speeds over 30 miles per hour is very fatiguing. After 8 hours' driving, accidents will increase and, when camp is reached, the end-of-the-day servicing of vehicles will be neglected.

Q. How is the movement of convoys over public highways coordinated with civilian traffic?—A. By means of rules promulgated by the Highway Traffic Advisory Committee of the War Department.

Q. What is done when the column is parked each night?—A. Gasoline, oil, and water are replenished and the vehicles are cleaned as well as possible by the drivers. The truckmaster (section leader) supervises this and checks up on all defects reported by the driver. The maintenance section immediately starts the necessary repairs, assisted by the driver. At night, lights must be placed on each vehicle, if parked on the road. A guard is usually detailed to protect the column. This work takes about 1½ to 2 hours each evening and no one should be dismissed until it has been completed.

Q. At what times are troubles most likely to develop within the convoy?—A. During the first hour or late in the afternoon.

Q. When should the first halt be made? Why?—A. The first halt should be made during the first hour, or as soon as the vehicles have warmed up. Minor adjustments and repairs made at this time will save much delay later on in the day.

Q. What is convoy discipline?—A. It is the observance and enforcement of the rules and regulations for convoys, especially as relates to the position of units in the column and the position and conduct of individuals and vehicles.

Q. Why is convoy discipline necessary?—A. It is necessary to insure adequate control; care of equipment; correct formations, distances, and speeds; and to enable the convoy to pass over roads with a maximum of speed and safety and a minimum of interference with other traffic.

Q. How is convoy discipline acquired?—A. Through training and experience.

**31. Speed laws and regulations.**—Q. What speed laws and regulations must be obeyed by the driver of a military motor vehicle?—A. Speed laws of the locality in which the vehicle is being operated and speed regulations posted in the vehicle.

**Q.** In your locality what are the maximum speed limits—

- (1) In a business district?
- (2) In a residential district?
- (3) For passenger cars?
- (4) For motorcycles?
- (5) For trucks?

**A.** The maximum speed limits are—

- (1) ----- miles per hour.
- (2) ----- miles per hour.
- (3) ----- miles per hour.
- (4) ----- miles per hour.
- (5) ----- miles per hour.

**Q.** How fast does one have to drive to be guilty of reckless driving?—**A.** At any speed which is too fast for conditions of traffic, weather, or the road.

**32. Parking.—Q.** What are a few “don’ts” with respect to parking? **A.—**

- (1) Don’t park on the roadway.
- (2) Don’t park on a bridge.
- (3) Don’t park in a defile.
- (4) Don’t park at the top of a hill.
- (5) Don’t park at any point where the vision of other drivers is restricted.
- (6) Don’t park so as to block cross traffic or entering side traffic.
- (7) Don’t park double.

**Q.** How is a convoy parked?—**A.** The principal requirements are sufficient space, solid ground, water, and toilet facilities. Do not park on ground where a sudden rain may mire the vehicles, or servicing at night cannot be performed properly. When it is necessary to park in column, leave only enough clearance between vehicles to allow any vehicle to get out.

**33. Road inspections.—Q.** When should a road inspection be made?—**A.** At each scheduled halt when in convoy; at intervals during the day when the vehicle is not in convoy.

**Q.** What is the object of a road inspection?—**A.** To detect and correct defects and to assure that the vehicle is ready for continued operation.

**Q.** What is the general procedure for making a road inspection of a vehicle? **A.—**

- (1) Allow the engine to run a short time. Listen for unusual noises.
- (2) Walk around the vehicle, looking carefully for fuel, oil, and water leaks.

(3) Inspect all tires for inflation, cuts, nails, stones, and indications of misalignment. On track-laying vehicles, examine tracks for adjustment and for worn, loose, broken, or missing parts. Note condition of traction devices, if used.

(4) Feel brake bands, wheel hubs, and gear cases for evidence of overheating.

(5) Inspect the lights, if traveling at night with lights.

(6) Check the amount of fuel in the tank.

(7) Check the quantity of water in the radiator.

(8) Check the quantity and condition of the oil in the crankcase or oil reservoir. Add oil if necessary.

(9) Inspect the condition of the cargo and towed load, if any.

(10) Report promptly the result of the inspection to the chief of section or other designated individual.

## SECTION VII

### MARCH RULES AND DISCIPLINE

|                     | Paragraph |
|---------------------|-----------|
| General .....       | 34        |
| Signals .....       | 35        |
| Traffic rules ..... | 36        |

**34. General.**—*Q.* What is a convoy?—*A.* Any group of motor vehicles organized to operate as a military unit in contrast to organically motorized tactical units or service trains.

*Q.* What is the purpose of a convoy?—*A.* The efficient transportation of personnel and matériel especially with respect to the time required and condition upon arrival.

*Q.* Define each of the following: Convoy commander, commander of troops, distance, guard, guide, march discipline, marker, regulating point, serial, and entrucking and detrucking points. *A.*—

(1) *Convoy commander.*—The officer in charge of the motor transportation and personnel of a convoy.

(2) *Commander of troops.*—The officer in command of the unit being transported. He may be also the march or convoy commander.

(3) *Distance.*—The space from the rear of one vehicle (including the towed load, if any) to the front of the next vehicle in column; or the space from the rear element of a leading unit to the leading element of the following unit.

(4) *Guard.*—An individual, preferably a noncommissioned officer, placed at an extremely sensitive point, such as a railroad crossing or a turn into or off a main road, to control traffic.

(5) *Guide.*—An individual who leads or guides a unit or vehicle over a predetermined route or into a selected bivouac area.

(6) *March discipline*.—That quality acquired through training and experience in marching which insures adequate march control; care of equipment; obedience to march restrictions; proper conduct and performance of duty by individuals; correct formations, distances, and speeds; and effective use of cover.

(7) *Marker*.—An individual, or distinctive object, placed at a critical point to indicate a position, direction, procedure, or obstacle.

(8) *Regulating point*.—An easily recognizable point where the incoming motor transport column is separated into detachments for entrucking or detrucking purposes.

(9) *Serial*.—One or more march units, preferably with the same march characteristics, placed under one commander for march purposes.

(10) *Entrucking and detrucking points*.—The points where the head of a truck column halts for the entrucking or detrucking of troops or supplies.

*Q.* What is the assigned minimum distance between trucks in convoy? *A.*—

(1) Open formation: 100 yards.

(2) Closed formation: Twice the speedometer reading in yards.

(3) At a halt: 2 yards.

(4) Between sections: 3 to 5 minutes' driving time.

*Q.* What are the driver's principal duties during a convoy? *A.*—

(1) Attention to orders and to his driving.

(2) Constant inspection before, during, and after operation.

*Q.* What should the driver do if he has any trouble while on the march? *A.*—

(1) If it is a major trouble he should pull to the side of the road and signal the following vehicle to pass. He should then report the trouble to the maintenance officer who is at the rear of the convoy. If he is left behind, the driver remains with his truck as a guard.

(2) If it is a minor trouble, the driver reports it to the section mechanic or maintenance officer at the next halt.

*Q.* What should the driver do during halts of a convoy? *A.*—

(1) He should make the prescribed inspections.

(2) He should keep to the right of his vehicle.

*Q.* In cold weather, what precautions should be taken against a delay in starting?—*A.* The drivers must be at their places in ample time to prepare their vehicles for the road so that the convoy can start on time.

*Q.* What is done when the column is parked each night?—*A.* Gasoline, oil, and water are replenished, and the drivers clean their vehicles as well as they are able. The truckmaster (section leader) supervises this and checks up on all defects reported by the driver. The main-

tenance section immediately starts on any repairs that may be necessary, assisted by the driver. This work takes from 1½ to 2 hours each evening, and no one should be dismissed until it has been completed.

**Q.** What are the duties of an assistant driver during a convoy? **A.**—

- (1) He assists the driver in backing, parking, etc.
- (2) He watches to the rear.
- (3) He takes his turn at driving.
- (4) He assists in first echelon maintenance.

**Q.** How is gasoline obtained in convoy? **A.**—

- (1) In an emergency, from the 10-gallon cans carried by the convoy.
- (2) At halts, from tankers or some type of filling station.

**35. Signals.**—**Q.** Describe the driver's arm signals. **A.**—

(1) *Turn right.*—Extend left arm outward at an angle 45° above the horizontal.

(2) *Turn left.*—Extend left arm outward horizontally.

(3) *Slow or stop.*—Extend left arm outward at an angle of 45° below horizontal.

(4) *Pass and keep going.*—Extend left arm horizontally and describe small circles toward the front with the hand.

**Q.** Describe the commands and signals commonly used in a motorized unit. **A.**—

(1) *Start engine.*—Simulate cranking.

(2) *Ready to start.*—The senior in the truck stands on the running board, facing the leader, and extends his arm vertically, fingers extended and joined, palm toward leader.

(3) *Stop engine.*—Cross arms in front of the body at the waist and then move them sharply to the side. Repeat several times.

(4) *Increase speed.*—Carry closed fist to the shoulder and rapidly thrust it vertically upward several times to the full extent of the arm.

(5) *Close up.*—Extend arms horizontally straight to the front, palms in. Move the hands together and then resume the first position, repeating several times.

(6) *Open up.*—Extend arms horizontally straight to the front, palms out. Move the hands outward and then resume the first position, repeating several times.

(7) *Danger.*—Use three long blasts of a whistle or automobile horn repeated several times or three equally spaced shots with a rifle or pistol. The person giving the signal points in the direction of the impending danger. This signal is reserved for warning of air or mechanized attack, or other immediate and grave danger.

(8) *Prepare to mount.*—Extend arm horizontally to the side, palm up, and wave the arm upward several times.

(9) *Prepare to dismount.*—Extend arm diagonally upward to the side, palm down, and wave the arm downward several times.

(10) *Report when ready to move.*—Extend arm vertically, fingers extended and joined. (Given by unit commander.)

(11) *Drivers to turn around simultaneously.*—Extend both arms horizontally toward the drivers and describe small, vertical circles, then signal forward in the desired new direction.

**36. Traffic rules.**—*Q.* What are some of the more general traffic rules? *A.*—

(1) Vehicles will keep to the right side of the road.

(2) The appropriate warning signal will be given before changing direction, slowing down, or stopping.

(3) The driver will be alert and pay attention to road signs, convoy signals, and traffic directions.

(4) The right-of-way will be given promptly to faster-moving vehicles.

(5) Speed will be reduced on dry, dusty roads.

(6) Lights will be dimmed when meeting another vehicle at night.

(7) Unnecessary use of horns is prohibited.

(8) Vehicles will be halted at railroad crossings not guarded by military personnel or civilian watchmen.

(9) Vehicles will clear the roadway before being halted.

*Q.* In passing oncoming vehicles, what should be done? *A.*—

(1) Pass on the right, giving at least half of the road.

(2) Slow down if operating conditions are hazardous.

(3) Permit the vehicle having a clear road ahead to have the right-of-way.

*Q.* What are some of the rules for passing vehicles traveling in the same direction? *A.*—

(1) Do not pass at a corner or blind curve.

(2) Do not pass on hills unless safe passage is assured.

(3) Do not pass at street intersections, crossroads, or on roads too narrow to leave at least 2 feet between vehicles.

(4) In passing, do not cut in or out too sharply.

*Q.* What rules governing speed should be observed? *A.*—

(1) The speed indicated on the caution plate, mounted on the vehicle, should not be exceeded.

(2) Drive slowly over rough, slippery, or congested roads.

(3) State or local speed regulations should be observed.

SECTION VIII

RECORDS AND REPORTS, MOTOR TRANSPORTATION

Paragraph

Records and reports----- 37

**37. Records and reports.**—*Q.* Where may a descriptive list of records and reports pertaining to motor transportation be found?—*A.* In AR 850-15, FM 25-10, and Circular 1-10, OQMG.

*Q.* What is the purpose of the records and reports required for motor transportation? *A.*—

(1) They protect the driver, the Government, and the claimant in case of an accident.

(2) They insure that Government transportation is being used to the best interests of the Government.

(3) They aid the maintenance personnel in maintaining the motor transportation.

*Q.* List the forms that are used in connection with motor transportation. *A.*—

(1) *Forms carried by driver.*

|   | Authority   | Form No.                      |
|---|-------------|-------------------------------|
| (a) Driver's Report—Accident, Motor Transportation. | AR 850-15-- | Standard Form No. 26.         |
| (b) U. S. Army Motor Vehicle Operator's Permit.     | AR 850-15-- | W. D., Q. M. C. Form No. 228. |
| (c) Driver's Trip Ticket and Performance Record.    | AR 850-15-- | W. D., Q. M. C. Form No. 237. |

(2) *Forms required in second echelon.*

|   | Authority   | Form No.                      |
|---|-------------|-------------------------------|
| (a) Investigating Officer's Report—Accident, Motor Transportation.  | AR 850-15-- | Standard Form No. 27.         |
| (b) Delivery Order and Receipt (gasoline and lubricant issue slip). | AR 35-6560- | W. D., Q. M. C. Form No. 437. |
| (c) Motor Vehicle Service Record Book (Pamphlet).                   | AR 850-15-- | W. D., Q. M. C. Form No. 248. |
| (d) Daily Dispatching Record of Motor Vehicles.                     | AR 850-15-- | W. D., Q. M. C. Form No. 254. |
| (e) Technical Inspection Report of Motor Vehicles.                  | AR 850-15-- | W. D., Q. M. C. Form No. 260. |
| (f) Ordnance Motor Book-----  | AR 850-15-- | W. D., O. O. Form No. 5956.   |
| (g) Lubrication, Work Order, and Bad Order Report Forms.            | AR 850-15-- | Improvised.                   |

(3) *Forms required by regimental supply officer or regimental motor officer.*

|  | Authority   | Form No.                                |
|--|-------------|---|
| (a) Data for Registration—Motor Vehicle.   | AR 850-15-- | W. D., Q. M. C. Form No. 220.           |
| (b) Motor Vehicle Transfer Form---   | AR 850-15-- | W. D., Q. M. C. Form No. 221.           |
| (c) Annual Physical Inventory Report of Motor Vehicles.  | AR 850-15-- | W. D., Q. M. C. Form No. 252.           |
| (d) Annual Report of Motor Vehicle Changes of Accountability.  | AR 850-15-- | W. D., Q. M. C. Form No. 253.           |
| (e) Abstract of Issues of Fuel, Forage, Gasoline and Oils, and Operating Supplies (Daily and Monthly). | AR 35-6560- | W. D., Q. M. C. Forms Nos. 438 and 440. |
| (f) Forms pertaining to the receipt, shipment, and issue of property.                                  | AR 35-6560- |   |

Q. In case of an accident what forms must be made out by the driver?—A. The accident report must be made out immediately at the scene of the accident.

Q. What should be the guiding factor in making out the reports required in case of an accident?—A. They should be so clear that there is no doubt in the mind of any reviewing authority as to how the accident occurred. Charts, pictures, affidavits, and receipted bills are used to make the reports clear.

Q. In case a claimant inquires for forms to make a claim as the result of an accident, what does one do?—A. Refers the claimant to the post adjutant who will furnish him the proper forms. It is contrary to regulations to furnish these forms or information concerning them except through official channels.

Q. Where can one find instructions as to how these forms are prepared and handled?—A. Instructions for the preparation of a particular form are usually contained on the form itself. In addition, Army Regulations contain a complete description, the Army Regulations applying to a particular form usually being listed on that form.

Q. How are tools issued and accounted for?—A. On memorandum receipt; but since the regular memorandum receipt form is too small and unsuited for this use, it is found more advantageous to use an improvised form for this purpose.

Q. How is replacement of parts secured?—A. By means of requisition upon a higher echelon.

Q. Where can data be found as to the records needed to obtain and salvage supplies and equipment?—A. In TM 10-310.

Q. What entries are made in the Motor Vehicle Service Record Book?—A. The annual vehicle mileage and a record of assignments,

repairs, accidents, and inspections. The service record book is designed to function also as a condensed instruction manual.

**Q.** What is the purpose of the form for routine scheduled lubrication?—**A.** To insure that the vehicle is properly lubricated and that no parts are overlubricated.

## SECTION IX.

### CARE, SERVICE, REPAIR, AND MAINTENANCE OF MOTOR VEHICLES IN FIELD

|   | Paragraph |
|---|-----------|
| Power plant-----                                | 38        |
| Cooling system -----                            | 39        |
| Gasoline feed system-----                       | 40        |
| Ignition system-----                            | 41        |
| Lubrication system-----                         | 42        |
| Clutch and transmission, wheels and brakes----- | 43        |
| Battery -----                                   | 44        |
| Miscellaneous-----                              | 45        |

**38. Power plant.**—**Q.** Explain briefly the basic principle involved in the operation of the internal combustion engine.—**A.** A combustible mixture of fuel (gasoline) and oxygen (air) is introduced into a cylinder and compressed between the closed end of the cylinder and a piston. The mixture is then ignited. The burning of the mixture generates heat which causes expansion. The expanding gases act on the piston inside the cylinder and force it downward. The movement of the piston is transmitted through a connecting rod to the crankshaft, thus converting heat energy into mechanical energy. (For nomenclature of typical valve mechanisms, see fig. 1.)

**Q.** What is meant by a four-cycle or four-stroke engine?—**A.** One whose cycle consists of four distinct steps as follows:

- (1) Intake or admission of the charge of the air-fuel mixture.
- (2) Compression of the charge.
- (3) Ignition and explosion of this charge.
- (4) Exhaust or expulsion of the burned charge.

When this complete process requires four strokes of the pistons in any one cylinder, the engine is designated a four-stroke cycle engine.

**Q.** Explain what takes place during each of the four strokes of the cycle. **A.**—

(1) The piston being at top dead center, the intake valve having just opened, the piston going down on suction draws into the cylinder a charge of gasoline and air.

(2) Shortly after the piston has passed bottom dead center, the intake valve closes and during the rest of the upward stroke the charge is compressed.

(3) Just before the piston reaches top dead center on the compression stroke, a spark is produced at the spark plug and the burning of the charge forces the piston downward. (This is the power stroke.)

(4) Just before the piston reaches bottom dead center the exhaust valve opens and the next upward stroke of the piston forces the burned gases out and clears the cylinder for the intake stroke of the next cycle.

Q. Why is a system of valves used in an engine?—A. To allow the fuel to enter the combustion chamber, to close the chamber, and to allow the burned gases to escape from the combustion chamber at the proper time.

Q. What is the function of the camshaft?—A. The camshaft has a cam for each valve. As the camshaft turns, the cam comes in contact with the valve lifter and raises the particular valve off its seat (opens it).

Q. How is the camshaft driven?—A. Either by a chain or system of timing gears driven by the crankshaft gear.

Q. What is meant by valve timing?—A. By valve timing is meant the proper adjustment of the opening and closing of the intake and exhaust valves in relation to the position of the piston. Since the distance of the piston from dead center is dependent on the position of the crankshaft, valve timing resolves itself into the proper meshing of the crankshaft gear with the camshaft gear to obtain this correct relationship.

Q. What is the result if a valve does not close all the way?—A. There is a loss of compression. If it is an exhaust valve, the seat will burn and warp, due to the hot escaping gases.

Q. What should the valve tappet clearance be?—A. The exhaust valve tappet should have about 0.006 to 0.012 of an inch. The inlet valve tappet should have about 0.004 to 0.010 of an inch.

Q. What is meant by a valve seat insert?—A. A very hard steel ring inserted in the valve port to form the valve seat.

Q. Is it possible to reseat valve seat inserts?—A. Only by the aid of special valve seat insert grinding stones.

Q. How often should they be resealed?—A. About every 50,000 to 65,000 miles. In some cases, they last the life of the vehicle.

Q. How is the compression of an engine tested?—A. Remove all spark plugs, open the throttle wide open, insert a compression gage in No. 1 cylinder, and crank the engine either by hand or battery about six revolutions. Take the reading of meter on a gage. If the reading is low, the compression is bad. Check each cylinder in the same manner. Compression in all cylinders should not vary more

than 5 pounds. If no gage is available, leave all spark plugs in place. Crank the engine by hand. Each cylinder should have about the same resistance when cranked against compression. A cylinder with good compression will show a springy resistance and the engine can be rocked against compression.

*Q.* What is the ratio of the camshaft to crankshaft speed?—*A.* The camshaft speed is half the speed of the crankshaft.

*Q.* How are the causes of engine troubles determined?—*A.* Since nearly all of the operating parts of the engine are inclosed and inaccessible, the cause of engine troubles must usually be deduced by a system of elimination.

*Q.* How can engine troubles be classed?—*A.* They can be classed as—

- (1) Mechanical troubles.
- (2) Fuel feed and carburetion troubles.
- (3) Ignition troubles.

*Q.* What conditions are necessary for an engine to start?—*A.* If the following conditions exist the engine should run:

(1) The engine turns freely without any indication of mechanical troubles and has compression.

(2) Gasoline reaches the cylinder, the cylinders being neither uncomfortably hot nor cold to the hand, the throttle being one-fourth open, and the intake passage clear and tight.

(3) There is a spark at the right time at the right place.

*Q.* Why is the power-producing unit of a motor vehicle called an engine instead of a motor?—*A.* To avoid any confusion with electric or starting motors.

*Q.* What inspection should be made whenever an engine is disassembled?—*A.* Inspect all parts for defects and make a list of all parts needed.

**39. Cooling system.**—*Q.* Should a water-cooled engine be run without water in the cooling system? Why?—*A.* No. It will cause the engine to run hot, and the metal will expand and cause the pistons and rings to seize the cylinder walls due to the burning of oil from the cylinder walls.

*Q.* If the engine is overheated, how should water be added?—*A.* Cold water should preferably be heated before being added. If this is impossible, the engine should be allowed to cool before water is added or water should be added very slowly.

*Q.* How should the radiator and water jackets be protected in cold weather?—*A.* A close check should be kept on the antifreeze solution. Unless sufficient antifreeze solution is used, the radiator and water jackets should be completely drained when the vehicle is not in use

and a "drained" sign should be hung on the radiator. Sometimes it will be necessary to protect the lower front half of the radiator with tin, cardboard, or canvas during operation.

**40. Gasoline feed system.**—*Q.* What type gasoline feed system is used on Army vehicles?—*A.* The positive fuel feed system (fuel pump) is used on all modern vehicles.

*Q.* What troubles most frequently develop in a fuel pump?—*A.* The diaphragm becomes punctured, gasoline lines become loose, or the strainer becomes clogged.

*Q.* What pump parts should be carried on a convoy?—*A.* A complete fuel pump for replacement use and a few extra diaphragms.

*Q.* What causes most fuel trouble in the field?—*A.* Dirt or water in the fuel. This will cause more trouble with Diesel engines than with others because of the small clearances used in Diesels.

*Q.* Name the most frequent carburetor troubles.—*A.* Strainers stopped up, jets stopped up, float too low or too high, and float punctured.

**41. Ignition system.**—*Q.* What is the function of the ignition system?—*A.* To ignite the charge of fuel at the proper time.

*Q.* What is meant by ignition timing?—*A.* Setting the ignition system so the breaker points will start to open at or just before the piston reaches top dead center on the compression stroke.

*Q.* What is the source of electrical power to operate the ignition system on the modern automobile?—*A.* The storage battery.

*Q.* Draw a wiring diagram of a typical battery ignition system.—*A.* See figure 4.

*Q.* What is the interrupter?—*A.* The interrupter is a mechanical switch which rapidly makes and breaks the primary circuit at intervals. When the primary circuit is broken, the primary current ceases to flow, thus causing the magnetic field around the coil to collapse. In so doing, it will induce a high voltage in the secondary coil having sufficient intensity to cause the secondary current to jump the spark plug gap.

*Q.* What is the purpose of the condenser?—*A.* The condenser is used in the primary circuit in parallel with the breaker points. When the breaker points open and the primary circuit is broken, the induced-kick voltage in the primary, which is in the same direction as the original battery current and which otherwise would cause an arcing across the breaker points, is impressed across the condenser and charges one side positive and the other side negative. The condenser will discharge back in a reverse direction through the primary windings. This backward surge of current will assist in reducing the magnetism of the core to zero, thus speeding up the collapsing lines of force and

thereby aiding in securing the maximum induced voltage in the secondary winding.

*Q.* What should the gap at the breaker points be?—*A.* It should be from about 0.013 to 0.022 of an inch.

*Q.* What should the spark plug gap be?—*A.* It should be from 0.025 to 0.035 of an inch.

*Q.* Name the most frequent causes of ignition troubles.—*A.* Improper timing, short circuit, burnt armature, defective contact points or brushes, and weak magnets.

(1) *Coil*.—Short-circuited, broken insulation.

(2) *Distributor*.—Broken contacts or brushes, water or dirt in distributor, distributor (or rotor finger) removed or broken, distributor head cracked.

(3) *Switch*.—Open circuit, short circuit, improperly connected.

*Q.* How can the timing of the spark be regulated to vary with engine speed?—*A.* By automatic spark control or by manual spark control.

*Q.* How are ignition troubles traced?—*A.* By asking oneself the following questions and finding the answers: Test for a spark at the spark plug. If there is no spark, is the switch turned on? Is the battery all right? Are any wires disconnected or terminals corroded? Are wires connected correctly? Are any wires broken? Do the breaker points open and close properly? Is there a spark at the spark plug at the proper time? Are spark plug gaps of the proper width? Are porcelains and electrodes clean and unbroken? Is there too much gasoline in the cylinders so the spark plugs are fouled?

*Q.* If, when the breaker points open, there is an excessive spark or arc at the point of opening, what is the trouble?—*A.* A disconnected or defective condenser.

*Q.* How is the fuel ignited in a Diesel engine?—*A.* The compression is so great that the heat generated by this compression is sufficient to ignite the fuel. If dirt enters the engine, the walls of the cylinders are liable to become scored, causing the compression to decrease. A loss of compression may cause the temperature induced to decrease to such an extent that ignition of the fuel will not take place and the engine will not operate.

**42. Lubrication system.**—*Q.* Name and explain the lubrication systems used in automobile engines.—*A.* The full-force feed, and the force feed (or pressure feed).

(1) In full feed, an oil pump, which is usually driven from the camshaft by means of gears, picks up the oil from the oil sump. The oil is then forced upward and conducted by means of tubes to the crankshaft bearings. These bearings become lubricated while the excess oil flows through holes drilled in the crankshaft and

through the throws of the crankshaft into the crankpins, lubricating the connecting-rod bearings. The oil is forced from the connecting-rod bearing through tubes or holes drilled in the connecting rods to the piston pins. This is the only system in which the oil is forced to the piston pins. In the full-force feed the camshaft bushings are also force-feed lubricated.

(2) In the force feed, the oil is pumped from the oil sump and forced to the crankshaft and connecting-rod bearings only. The piston pins and cylinder walls are lubricated by splash.

*Q.* Why are oil filters used?—*A.* To remove the dirt and grit from the oil.

*Q.* How are lubricating oils classified?—*A.* Lubricating oils are classified according to their viscosity by an SAE rating. By this rating the higher number is given to the heavier oil. Oil with an SAE No. 50 rating is a thick oil, while No. 20 is a thin oil.

*Q.* How is the transmission lubricated?—*A.* By heavy oil contained in the transmission.

**43. Clutch and transmission, wheels and brakes.**—*Q.* Name the most usual clutch troubles.—*A.* Slipping, grabbing, and chattering.

*Q.* What are the causes? *A.*—

(1) Slipping is usually caused by the friction material of the disk being worn, the clutch springs failing to exert sufficient pressure, or from allowing the foot to rest on the clutch pedal while driving.

(2) Grabbing is caused by oil on the clutch plates, spring with too great a capacity, or faulty lining.

(3) Chattering is caused by the clutch shaft and driving members being out of alinement with the driven member.

*Q.* To what are most clutch troubles due?—*A.* They are due to the clutch throw-out bearing becoming worn.

*Q.* Name the most usual transmission troubles and their causes.—*A.* Difficulty in shifting gears, usually caused by broken parts, by oil which has become gummy, insufficient or too much oil, or from the gear shift lever connections being out of order. The transmission gear can easily be stripped by changing from a forward to a reverse gear when the vehicle is in motion.

*Q.* What troubles may develop in the drive?—*A.* Broken drive shaft or universal joints. The drive shaft may break or be bent by contact with road obstructions, by excessive differential gear clearance, or by racing the engine and jerking the vehicle by suddenly applying the power to the axle shafts.

*Q.* How is the power transmitted to the rear axle?—*A.* Through universal joints and a drive or propeller shaft. Four-wheel-drive

trucks employ two-drive shafts and require what is known as a transfer case or differential for this purpose.

*Q.* What is a universal joint?—*A.* It is a device for connecting two shafts which are slightly out of alinement, and to transmit power through these angles.

*Q.* What is a slip joint?—*A.* A sliding or telescopic joint which is splined and permits variations in the length of the drive shaft. It is used to compensate for the variations in distance between transmission and rear axle, due to the action of the springs.

*Q.* What is the purpose of the differential?—*A.* It permits one axle shaft connected to it to rotate slower, faster, or remain stationary with reference to the other axle shaft. Such a device is necessary to compensate for the difference in speed of the rear wheels when going around curves.

*Q.* Can the auxiliary transmission be shifted into a lower gear while the vehicle is in motion?—*A.* Regulations prohibit such a shift, as there is a great possibility of stripping the gears.

*Q.* Explain the principle embodied in the design of the bevel differential.—*A.* The differential case is attached to and driven by the ring gear. Four small bevel gears are mounted inside the differential case on a spider, the latter supported by the case. The four gears are in mesh with a bevel gear on each side, to which the axle is attached. On a straight road with equal traction, the motion of the ring is transmitted to the differential case; the spider gears remain stationary and cause the gears attached to the axle shafts to rotate in unison with the case. If one axle is retarded or stopped, as in rounding a curve, the gear attached to that axle is moving slowly or is stationary. The differential case being in motion turns the spider. The spider gears roll on the gear attached to the retarded or stationary axle, while the gear attached to the other axle is rotated at a higher speed. If one wheel stops, the other one will turn twice as fast as it did before the other wheel stopped.

*Q.* How is the power transmitted to the ring gear?—*A.* From the propellor shaft to a piston shaft, to the pinion gear, to the ring gear.

*Q.* Explain the double-reduction-drive differential.—*A.* The only difference is that the first reduction is from the bevel-ring gear shaft to a small spur gear, to a large spur gear connected to the differential case.

*Q.* What is the advantage of dual wheels?—*A.* They give greater carrying capacity, longer tire life, increased road contact, with consequent better traction, while the tires can be smaller in diameter, giving a lower center of gravity to the vehicle.

**Q.** Describe briefly the construction of a typical steering gear.—**A.** The steering wheel is keyed to a shaft supported by the steering column. The shaft terminates in a worm; the worm engages in a worm gear, the shaft of which carries the steering lever arm. The steering lever arm is connected by the drag link to one of the steering knuckles. A tie rod connects the two steering knuckles.

**Q.** Explain the mounting of the front axle and wheels.—**A.** The front axle is fastened to the frame by means of leaf springs, which are secured to the frame by shackles and shackle bolts. The axle is fastened to the springs by bolts. The wheels are mounted on spindles; the spindle is fastened to each end of the axle with kingpins which allows the spindle to turn.

**Q.** Why are the steering arms curved toward the center of the vehicle instead of being straight?—**A.** Because in turning a curve the path of the outside wheel is an arc of a larger circle than the path of the inner wheel. Therefore, the outside wheel must be inclined at a lesser angle than the inside wheel. The angularity of the steering arms provides for this difference in inclination of the wheel.

**Q.** What difficulties are experienced with the steering mechanism?—**A.** Front wheels out of alinement, broken parts, improper lubrication, and parts becoming worn and loose.

**Q.** What is meant by irreversible steering gear?—**A.** A steering gear in which turning motions can be transmitted to the steering knuckles by turning the steering wheel, but motions cannot be transmitted from the front wheels to the steering wheel.

**Q.** How is this accomplished?—**A.** By the use of a worm in the steering gear. A worm is capable of turning a gear, but the motion cannot readily be transmitted from a gear to a worm.

**Q.** What troubles are experienced with wheel bearings?—**A.** Improper adjustments and insufficient lubrication.

**Q.** How are brakes operated?—**A.** Mechanical, hydraulic, or air operated. A vacuum booster may be used to work in conjunction with the mechanical or hydraulic brake.

**Q.** What is the advantage of the vacuum booster brake?—**A.** It lessens the necessary brake pedal pressure for brake application.

**Q.** What troubles are experienced with brakes?—**A.** Worn-out brake lining, unequal adjustment of the brake bands or shoes, scored drums, brake lining stripping from the shoes and rolling up at the ends, oil leaks in the lines, brake, or master cylinders in the case of hydraulic brakes, unequal linkage and rod adjustments, and oil on brake lining.

*Q.* What precautions must be taken with brakes?—*A.* Brakes must be tested and inspected frequently, worn lining must be replaced, and the brake bands kept in proper adjustment.

*Q.* How can the wear of the brakes be reduced?—*A.* By using the engine to produce braking effect. In descending long, steep grades the vehicle should be run in second or low gear to help brake the vehicle.

*Q.* When does the greatest braking effect occur?—*A.* Just before the wheels begin to slide.

*Q.* What care should be taken of tires?—*A.* Keep sufficient air pressure in them, keep rims tight, and avoid running over glass or sharp stones as much as possible. Do not run on a flat tire. Never let a tire sit in oil or gasoline, as it will rot the rubber.

**44. Battery.**—*Q.* When a new battery is received what is the first thing to do?—*A.* Unpack the battery, keeping the packing case right side up to avoid spilling the battery solution. Examine the battery carefully to see if there is any indication of injury during transit. Determine whether the battery has been shipped charged or unfilled.

*Q.* What care is necessary when installing a battery on a car?—*A.* When connecting the battery to the battery cables, be sure they are connected properly and are tight, and the terminals are greased with vaseline or some lubrication grease.

*Q.* How can it be determined whether the battery is properly connected?—*A.* Look up the diagram in the service book, or turn the lights on and note the reading of the ammeter. If the engine is not running, the ammeter should indicate discharge if the battery is properly connected.

*Q.* What attention does the battery require in service?—*A.* It requires very little attention, but that little is absolutely necessary and vital. Add nothing but pure distilled water to replace that lost by evaporation. Do this often enough to keep the plates covered about one-half inch. In freezing weather do not add water until just before the battery is to be used or recharged. Keep the connections tight and covered with vaseline. Keep the filling plugs tight and battery dry, clean, and clamped down tightly in the carrier. Take hydrometer readings and check water every 2 weeks in the summer. If the vehicle is put in storage or held for repairs the battery should be removed, charged, and put into proper storage.

*Q.* How should corroded battery terminals be cleaned?—*A.* By scrubbing thoroughly with ammonia, or a solution of baking soda and water.

*Q.* What will cause the lights to burn out?—*A.* Loose battery connections, reverse current relay points sticking, or lamp bulbs of the wrong voltage.

*Q.* If lights go dim when engine is cranked with the electric starter, what is the trouble?—*A.* Discharged battery or loose battery connection.

*Q.* In case of trouble with the electric starter, what should be done?  
*A.*—

- (1) See that the battery is charged.
- (2) See that there are no short circuits.
- (3) See that battery terminals are not loose, rusty, or corroded.
- (4) Examine the starting switch for proper connections and operation.

- (5) See that the brushes are properly seated on motor commutator.

**45. Miscellaneous.**—*Q.* What repairs are permitted in the field?—*A.* The repairs are limited by the supplies and equipment on hand, and the ability of the personnel.

*Q.* What records are required to be kept in the field by the chief of section?—*A.* The Motor Vehicle Service Record Book and such improvised forms as are necessary to collect data for the Motor Vehicle Service Record Book.

*Q.* What data are kept in the Motor Vehicle Service Record Book?  
*A.*—

- (1) Abbreviated instructions for the care and maintenance of the motor vehicle described on the cover of the record book.
- (2) Mileage record.
- (3) Accident record.
- (4) Description of all repairs done.
- (5) Tool and property record.
- (6) Assignment record.

*Q.* Who is in charge of issuing gasoline, lubricants, and motor vehicle supplies in the field?—*A.* The regimental supply officer, assisted by the transportation (motor) officer.

## CHAPTER 3

### COMMUNICATION

|   | Paragraphs |
|---|------------|
| <b>SECTION I. Systems of communication</b> .....                                | 46-49      |
| II. Visual signaling—panels.....  | 50         |
| III. Installation of field telephone system.....                                | 51-53      |
| IV. Location of faults; tests for grounds and short<br>circuits.....            | 54         |
| V. Installation and operation of message centers;<br>encoding and decoding..... | 55-56      |
| VI. Linemen and telephone and switchboard operators                             | 57         |
| VII. Dissemination of alarms; records and reports.....                          | 58-59      |

#### SECTION I

#### SYSTEMS OF COMMUNICATION

|                   | Paragraph |
|-------------------|-----------|
| General.....      | 46        |
| Telephones.....   | 47        |
| Switchboards..... | 48        |
| Circuits.....     | 49        |

**46. General.—Q.** Name several of the means of communication commonly used by mobile artillery.—**A.** Telephone; radio; visual signals including wigwag, semaphore, and panels; motorcyclists, orderlies, and runners.

**Q.** Which of the above means of communication is most suitable for fire control?—**A.** The telephone. The other systems are supplementary and may be used in emergency.

**Q.** What two types of telephone systems are used?—**A.** Common battery and local battery systems.

**Q.** What feature distinguishes the local battery telephone system from the common battery telephone system?—**A.** In a local battery system batteries are connected locally to each telephone used. In a common battery system all telephones are energized by a storage battery at a central station.

**Q.** Which system is generally used in—

- (1) Fixed seacoast artillery installations?
- (2) Mobile seacoast artillery units?
- (3) Antiaircraft artillery units?

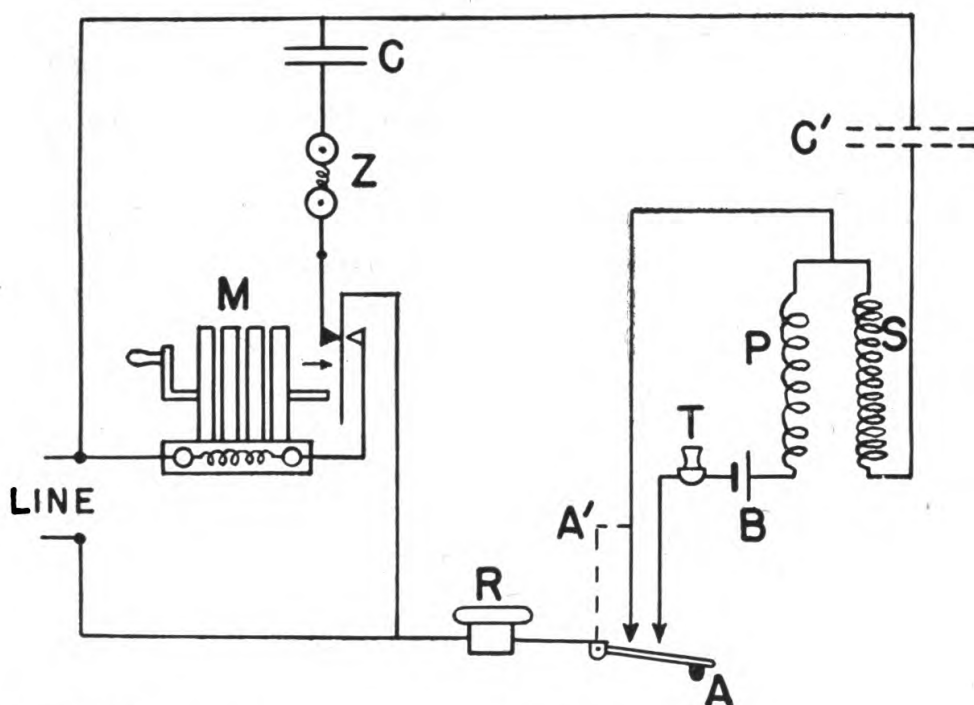
**A.** The following systems are used:

- (1) Fixed installations generally use the common battery system.

(2) Mobile seacoast artillery units generally use the local battery system.

(3) Antiaircraft artillery units generally use the local battery system.

*Q.* Can the same type of telephone be used on local and common battery circuits?—*A.* The internal circuits of common battery telephones differ from the circuits of the local battery type. Several types of local battery telephones can be connected to a common battery system, but it is necessary to use a local battery for each telephone so connected.



- |  |   |
|--|---|
| A. Push button.                        | P. Primary coil.                            |
| A'. Jumper in handset of new type.     | R. Receiver.                                |
| B. Local battery.                      | S. Secondary coil.                          |
| C. Condenser.                          | T. Transmitter.                             |
| C'. Position of condenser in new type. | Z. Buzzer (substituted for bell or ringer). |
| M. Magneto.                            |   |

FIGURE 10.—Simplified circuit of type EE-5 telephone.

*Q.* Can the EE-5 telephone be used on a common battery system?—*A.* Only the unmodified EE-5 telephone can be used on a common battery system. The modified EE-5 telephone requires the use of a condenser in series with the line in order to prevent direct current flow through the ringing circuit.

*Q.* Explain why a local battery is necessary when a local battery telephone is used on a common battery circuit.—*A.* The local battery is necessary to energize the primary circuit, including the transmitter.

**47. Telephones.**—*Q.* Name the principal circuits of the telephone.—*A.* The primary circuit, consisting of the battery, transmitter, and primary winding of the induction coil; the secondary circuit, consisting of the secondary winding of the induction coil, the receiver, and the receiver condenser; and the ringing circuit, consisting of the magneto and ringer or buzzer.

*Q.* How are the magneto and buzzer connected?—*A.* The circuits of both are bridged in parallel across the line. The magneto switch is so connected, however, that either the magneto or the buzzer will be connected at one time; both cannot be connected across the line at the same time.

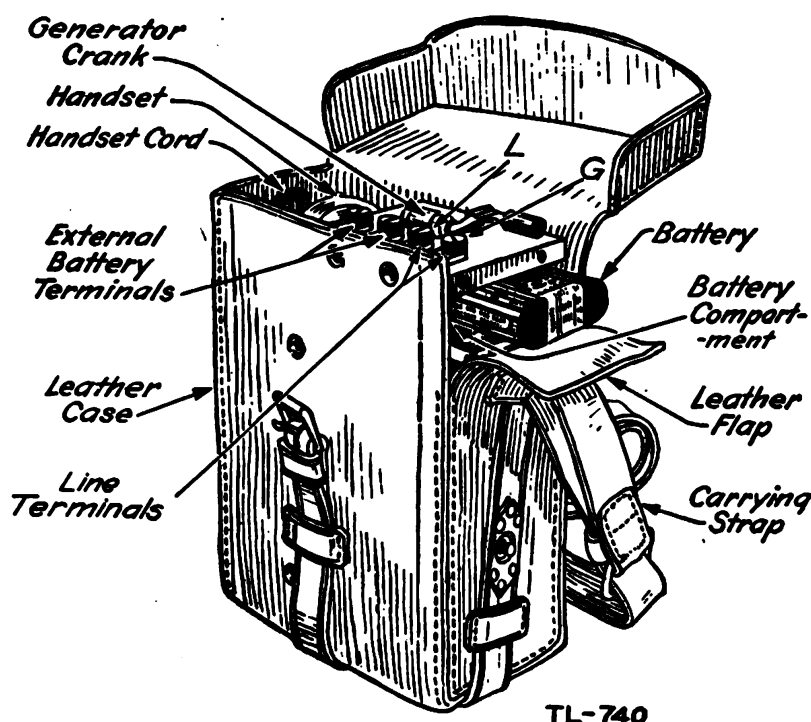


FIGURE 11.—Field telephone, type EE-5.

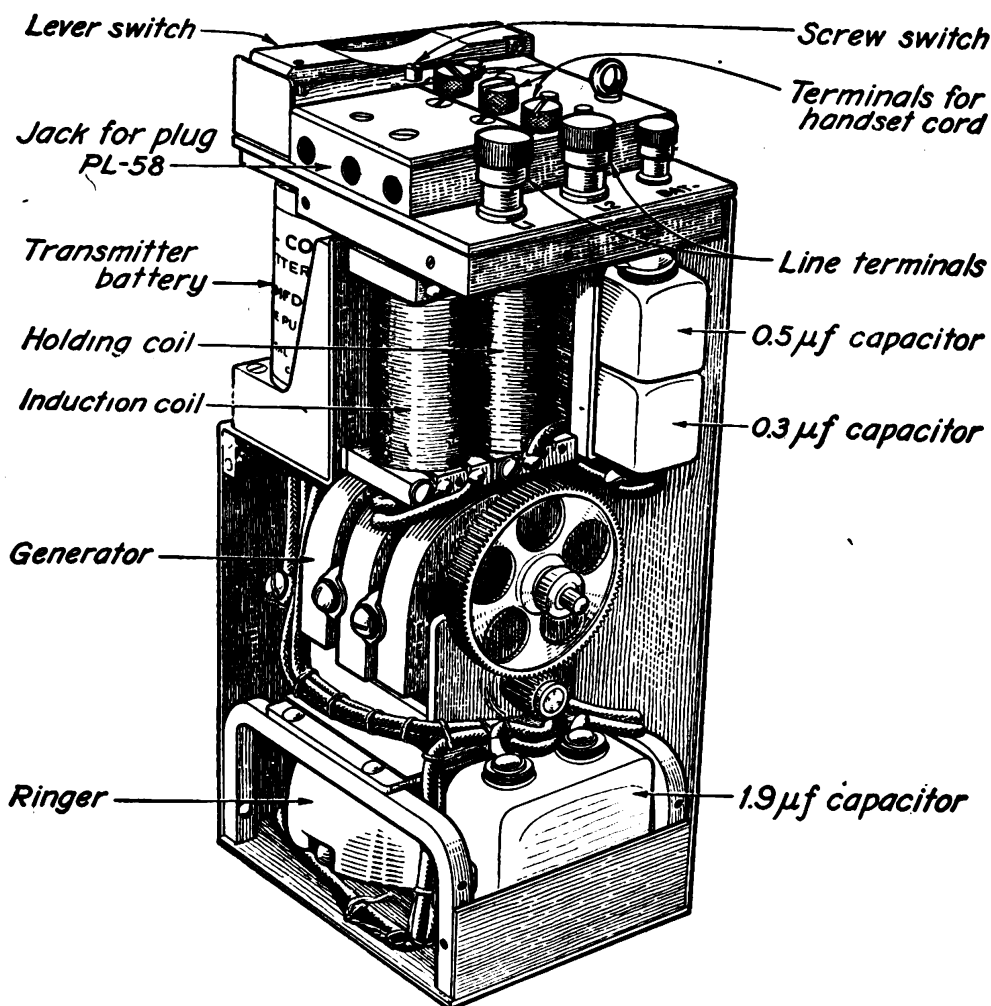
*Q.* Is the current generated by the magneto transmitted through the receiver and transmitter?—*A.* No. A button switch on the unmodified EE-5 telephone disconnects both receiver and transmitter from the magneto circuit. On the modified EE-5 and the EE-8 or EE-8A, the handset switch disconnects the transmitter only, but the receiver condenser offers such high impedance to the low-frequency ringing current that in effect very little ringing current passes through the receiver.

*Q.* What type transmitter and receiver is used with the type EE-5 telephone?—*A.* Handset type TS-7.

*Q.* Is the type TS-7 handset suitable for all conditions of service?—*A.* No. For operation against naval targets when constant

and prolonged telephone connections are necessary, the headset, type EE-70 should be used. However, this is to be considered exceptional, as the use of this headset necessitates internal connection to the telephone.

*Q.* What is the distinguishing feature of the EE-8 telephone, compared to other local battery telephones?—*A.* The EE-8 telephone is an anti-sidetone telephone, in which an auxiliary receiver circuit



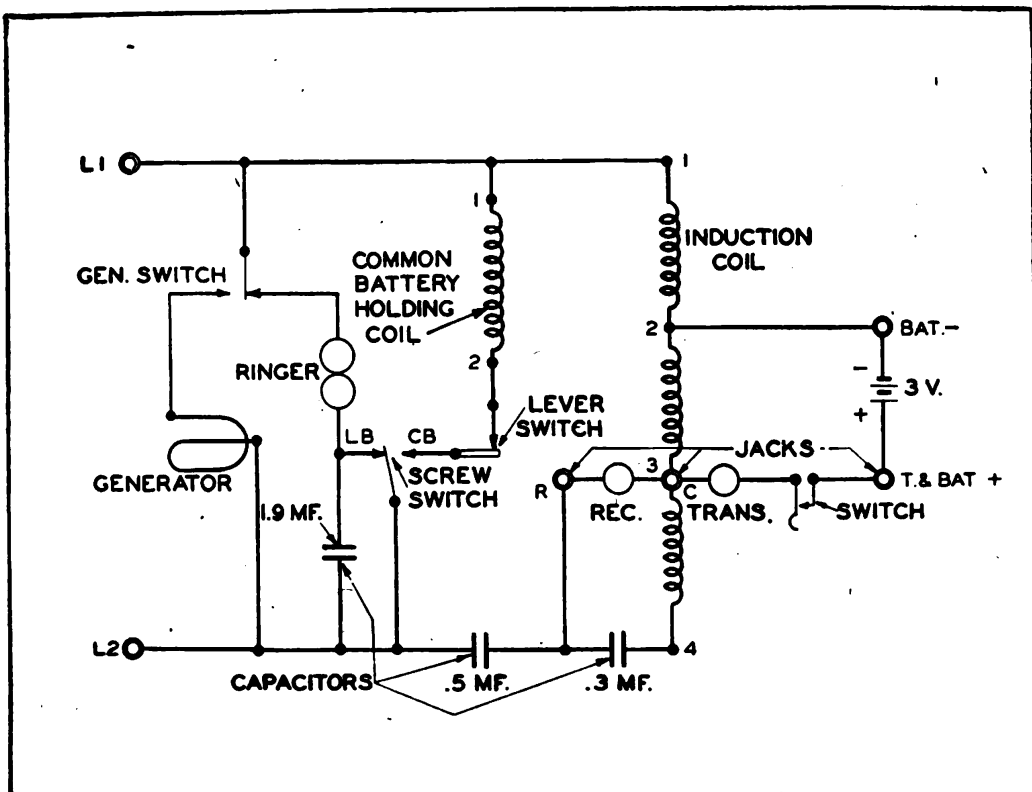
TL-1698

FIGURE 12.—Field telephone, type EE-8, showing interior view of frame assembly.

partially suppresses sidetone in the receiver while the operator is using the transmitter.

*Q.* Can the EE-8 telephone be used on common battery systems?—*A.* Yes. The EE-8 telephone may be used on common battery systems by simply changing the position of the “LB-CB” switch. Turning this switch to the “CB” position connects a holding coil in such a manner that lifting the handset from the lever switch will connect the holding coil across the line and thus signal the switch-

**Q.** How does the EE-8 telephone differ from the EE-8A?—**A.** In the EE-8A telephone the small, flexible insert in the cover is



SC-D-1782-D

**Q.** Is it necessary to hold the diaphragm of the transmitter in a vertical plane?—**A.** No. The transmitter in the EE-8 telephone has been so improved over older transmitters that it will operate equally well in all positions.

**Q.** What will happen if the "LB-CB" switch is turned to "CB" and the generator operated with the lever switch up?—**A.** The called ringer will not operate properly, due to the fact that a considerable part of the generator current will flow through the holding coil on the calling telephone.

**Q.** Where may detailed information on the EE-8 telephone be obtained?—**A.** In TR 1225-10 or TM 11-333.

**48. Switchboards.**—**Q.** What type switchboard is used with the battalion and battery telephone system?—**A.** Monocord switchboards are normally used. There are four types available: BD-9, a 4-drop monocord switchboard without operator's set or night alarm; BD-11, a 12-drop monocord switchboard without operator's set or night alarm; BD-71, a 6-drop monocord switchboard with operator's set, night alarm, and two repeating coils; and the BD-72, a 12-drop monocord switchboard with operator's set, night alarm, and four repeating coils.

**Q.** Name the principal parts of the switchboard, type BD-9.—**A.** The switchboard frame; the three brass bars; seven binding clips, three on top and four on the bottom of the frame; and the switchboard units.

**Q.** What is the purpose of the binding clips?—**A.** The three upper ones, marked A, A-1, and G, are used to connect the night bell and the ground. Of the four lower ones marked B, B-1, L-1, and L-2, B and B-1 are used to connect the night bell battery, and L-1 and L-2 are connected to the operator's telephone set and plug. By connecting L-1 and L-2 of one switchboard to L-1 and L-2 of another, two switchboards may be used together as one.

**Q.** What is the purpose of the brass bars?—**A.** In addition to providing a mechanical support for the units, the top bars serve as a good ground connection, the center bar as night bell connection, and the bottom bar as battery connection for all units.

**Q.** Name the principal parts of a type EE-2 switchboard unit.—**A.** Mounting screws, line terminals, lightning arrester, fuses, line signal shutter and electromagnet, night bell contact and spring, and jack and line plug.

**Q.** Explain the operation of a lightning arrester.—**A.** It consists of a toothed washer held between the line binding posts by the upper mounting screw and ground through the upper brass bar. If lightning comes in over one of the line wires, the main portion jumps the gap between the binding post and washer and thence to the ground. If the small portion flowing through the switchboard units is at all heavy the fuses burn out, opening the circuit.

**Q.** Describe the fuses.—**A.** Each unit is provided with two glass-inclosed fuses, which fit into spring contacts to protect each side of the

line from excessive currents. The panel is painted white behind the fuses so that a burnt fuse, usually smoked up, can be readily noticed.

*Q.* Explain briefly the operation and construction of the signal shutter and coils.—*A.* The shutter, or drop signal, is normally held in a vertical position by a brass trip latch. The trip latch is attached to the armature of a small electromagnet. The coils of the magnet are connected through the jack to the line. The current from the calling station energizes the electromagnet. The latter attracts and lifts the armature and trip latch. The shutter drops, by its own weight, to a horizontal position.

*Q.* Explain the operation of the night bell contact.—*A.* When the signal shutter drops, the night bell spring and contact are brought together, completing a circuit from a battery to the lower brass bar, through the night bell spring and contacts to the center bar, thence to the night bell. The bell continues to ring until the shutter is raised or battery disconnected.

*Q.* Describe briefly the switchboard jack and plug.—*A.* The jack consists of a cylindrical opening in the panel of the unit, behind which are mounted the tip contact, the sleeve contact, and the signal contact. The tip contact is connected through one of the fuses to one side of the line, the signal contact to the other through the magnet coils and the other fuse. The plug is cylindrical, having two contacts, one on the tip through the center of the plug, and the other on a sleeve on the outside of the plug. These contacts are connected by two wires, inclosed in a single covering, to the tip and sleeve contacts of the jack, respectively.

*Q.* How do the plug and jack operate?—*A.* When the plug of a unit is inserted in the jack of a second unit, the line of the first unit is connected to the line of the second unit. This completes the circuit between the two lines. In addition, the operator may plug into the unit having a vacant jack and listen in. When the plug is inserted, the tip and signal contacts are separated. This opens the circuit to the coils of the shutter magnet.

*Q.* What care is required in transporting, installing, and using the switchboard?—*A.* In transporting and installing the board, all shutters are held closed by the spring lever provided on each unit. When the switchboard is installed it is necessary that the frame be held in a vertical and level position. In handling switchboard cords, they should be grasped by the plug and not by the cord, in order to prevent breaking the cord.

*Q.* What is the cause of a short circuit between lightning arrester and line?—*A.* Particles of dirt. The small clearance between the arrester and line contacts must be kept clean.

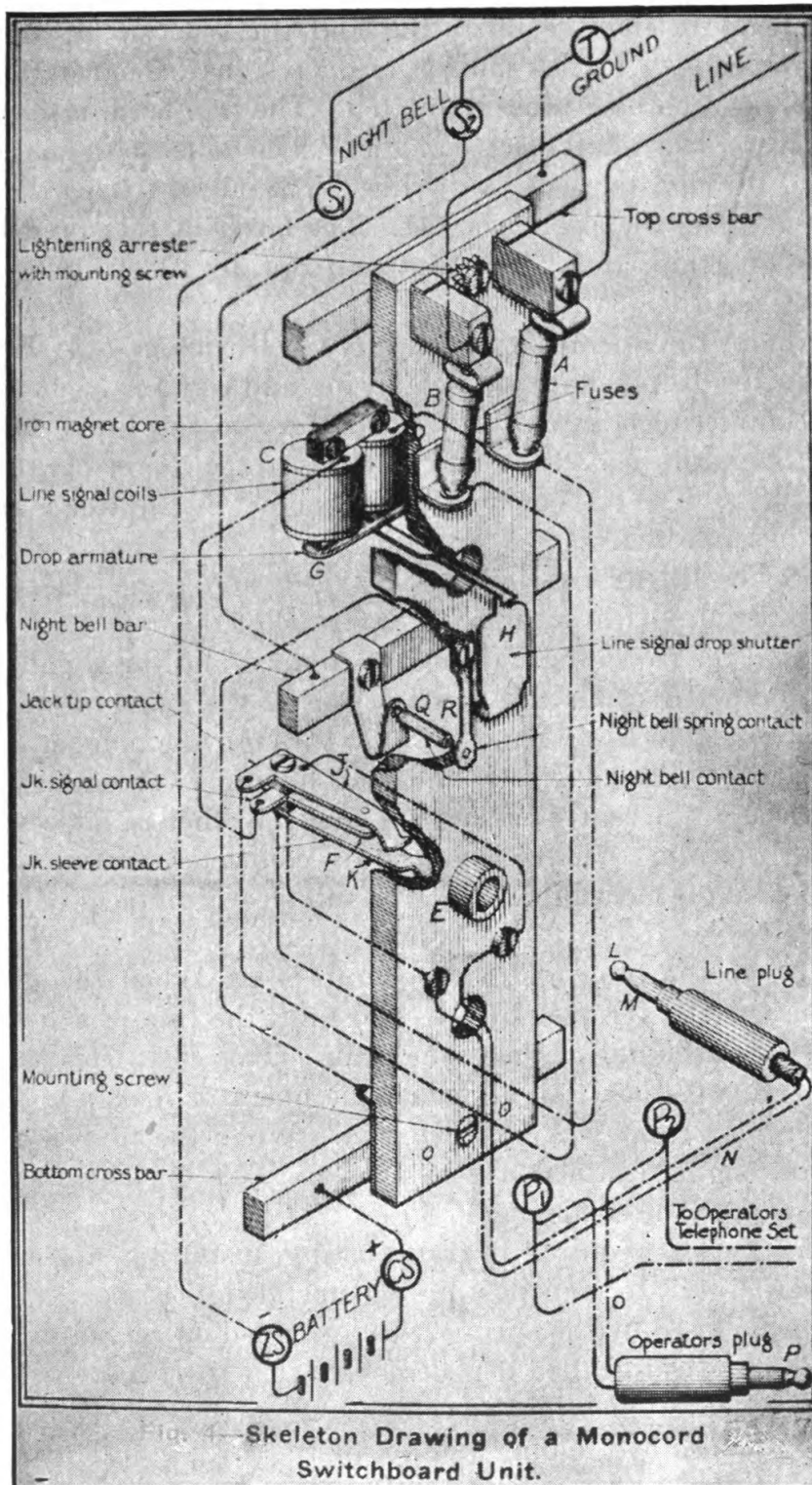


FIGURE 14.—Diagram of monocord switchboard unit.

Q. Should the night bell continue to ring after the shutter is raised, how is the trouble remedied?—A. By adjusting the night bell contact spring so that a small space is left between it and the contact point.

Q. Should the signal shutter fail to drop when the magnet is energized, what remedy is applied?—A. By removing the unit, the armature and trip catch may be adjusted so that the catch is clear of the shutter when the armature is raised; also be sure the face of the board is vertical.

Q. What should be done if an open circuit develops in one of the shutter coils?—A. The switchboard unit should be replaced.

Q. What remedy is applied when the plug fails to make proper connections?—A. The tip and sleeve contacts on the jack are cleaned and adjusted so that they come into firm contact with the plug when inserted.

Q. How may a switchboard cord be tested to insure that the wires are in operating condition?—A. Insert the plug of the operator's unit in the jack of the unit to be tested. Ring the operator's set, while holding the tip and sleeve of the cord jack. If the cord is good, the current will be felt by the fingers. If no current is felt, the cord may be open, in which case the magneto crank will turn easily, or it may be shorted, in which case the crank will be hard to turn.

Q. Should the operator's cord be found defective, how can operation of the board be continued?—A. By three different methods, as follows:

(1) Transfer the wires from L-1 and L-2 to the line terminals of a unit not in use, and use the cord of that unit as the operator's cord while the latter is being replaced.

(2) Connect the terminals of an extra unit directly to the terminal of the operator's set, and use this as a master cord while replacing the defective one.

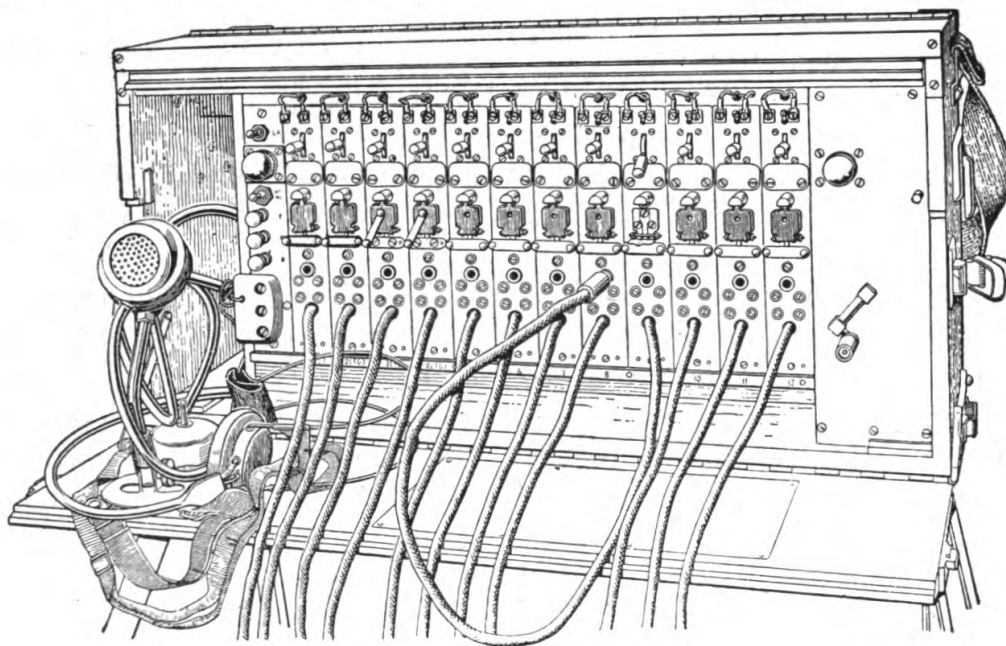
(3) If an extra plug is available but no extra cord, and there are no spare units on the board, remove the paper sleeve from the handle of the plug and transfer the wires from L-1 and L-2 to the terminals of this plug. This plug can then be used as a master plug until repairs are made.

Q. How is the operator's cord replaced?—A. The cord connections are made accessible by removing two units to the right of the point where the cord goes up through the bottom of the board. The new cord is run up through the bottom of the board and connected. The two units are then replaced.

Q. What extra parts should be kept available at all times?—A. Several extra fuses, extra cords with plugs, extra complete units, and some light, twisted repair wire. In addition, a lineman's repair kit should be available.

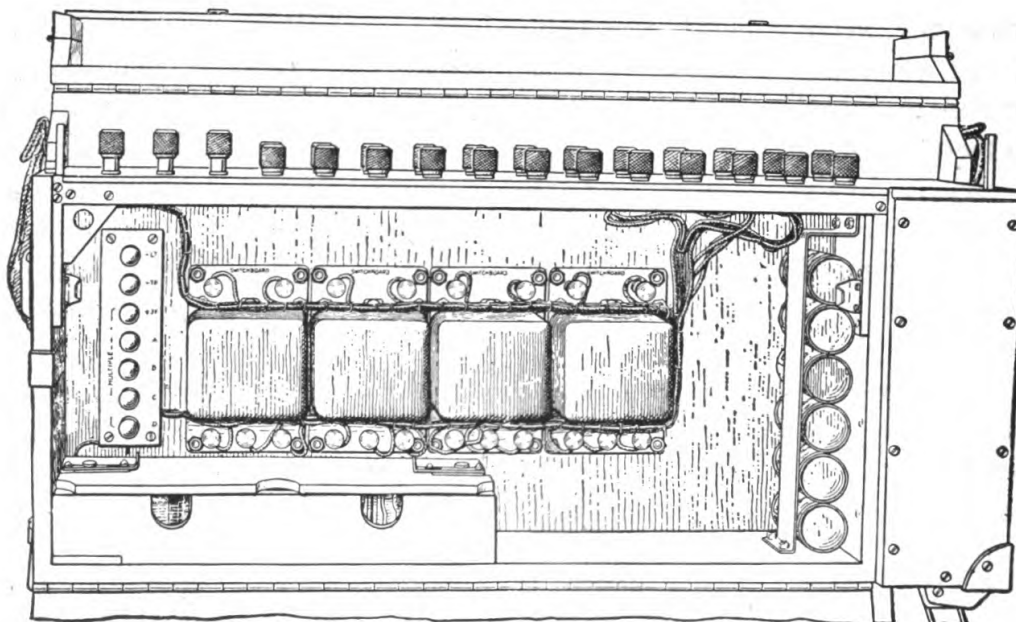
Q. What kind of telephone is used as an operator's set?—A. Any local battery telephone is suitable for use as an operator's set.

Q. How does the EE-2B switchboard unit differ from the EE-2 switchboard unit?—A. In the EE-2B switchboard unit, the fuses are omitted and a talk-ring switch substituted. With the talk-ring switch, it is possible for the switchboard operator to talk to or ring any telephone connected to the switchboard.



① Front view open.

SCL-3



② Rear view open.

SCL-4

FIGURE 15.—Switchboard, type BD-72, original from

Q. What are the principal circuits of the BD-71 and BD-72 switchboards? A.—

Line

Line

Talk (L)

Ring (NL)

0.5  $\mu$ f

0.3  $\mu$ f

— Talking and ringing circuits  
 --- Night alarm circuit

NOTE - Key springs move opposite to direction key is moved:

RING (non-locking)  
 TALK (locking)

TL-1691

**TL-1691**

(2) Operator's telephone circuit.

(3) Night alarm and lighting circuit.

Q. What additional equipment is furnished with these switchboards?—A. Two repeating coils in the BD-71 switchboard and four in the BD-72 switchboard, plus a terminal strip for incoming telephone lines, and a terminal strip for paralleling two switchboards.

Q. Should the operator bridge his telephone across two lines which are in use in order to assist in the transmission of information?—A. No. The additional loss caused by the operator's telephone may make conversation impossible between the two parties connected through the switchboard. The operator should only keep his telephone connected long enough to supervise the connection.

Q. If two separate conversations are taking place through a BD-71 or BD-72 switchboard, what will happen if the operator depresses the talk-ring switches on two of the switchboard units, one of which is being used on one conversation and the other of which is being used in the second conversation?—A. All four telephones will be connected to the switchboard operator's telephone and to each other, causing cross talk.

Q. Where may detailed information be obtained covering the BD-71 and BD-72 switchboard?—A. Detailed information may be obtained in TR 1225-1.

Q. Describe the operation of replacing a switchboard unit.—A. The two line connections on the line terminals at the top of the unit are first disconnected. The two filister-head screws are then removed, one at the top of the switchboard panel and the other at the bottom of the panel. The unit is removed carefully, and when it is clear of the frame the two connections to the bus bars are unscrewed and the unit withdrawn. To replace, reverse the above operations, being careful to make the bus connections exactly the same as on the other units. In both the above operations, care must be taken to protect the shutter drop. It should be locked in the closed position by means of the small locking lever.

Q. What is the use of the repeating coils?—A. The repeating coils may be used in simplex circuits for telegraphy, or in phantom circuits for telephony. One repeating coil is required on each switchboard for each telegraph circuit with ground return, and two repeating coils are required on each board for a telephone phantom circuit.

Q. With the repeating coils used in a phantom circuit, is it possible to signal the switchboard from one of the telephones connected

to the phantom portion of the circuit?—A. No, because there will be no complete circuit through one of the switchboard shutter magnets.

Q. In case the operator's telephone becomes inoperative, what may be done to permit the use of the switchboard?—A. An ordinary

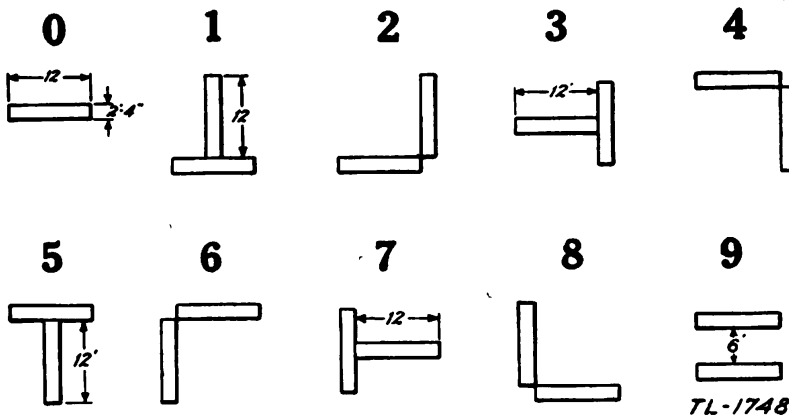


FIGURE 17.—Panel numerals.

local battery field telephone may be used by connecting the spare switchboard cord to the line terminals of the telephone and either using the handset of the field telephone or the headset of the switchboard telephone. In this system the switchboard is used in a manner similar to the BD-9 switchboard, and the talk-ring switches are not used. If a spare switchboard cord is not available, the field telephone may be connected to the line terminals of one of the switchboard units, and the cord of the unit so connected used as the operator's cord.

Q. What will happen if a lightning stroke hits a line connected to the BD-71 or BD-72 switchboard?—A. Most of the energy of the lightning stroke will pass to ground over the lightning arrester gap from each line terminal to the ground strip in the switchboard.

49. Circuits.—Q. What is meant by ground return?—A. When a single wire line is used, the other terminal of the telephone is connected to a rod or other metallic substance set or buried in the ground or in a tree, thereby using the earth as a conductor for the return circuit.

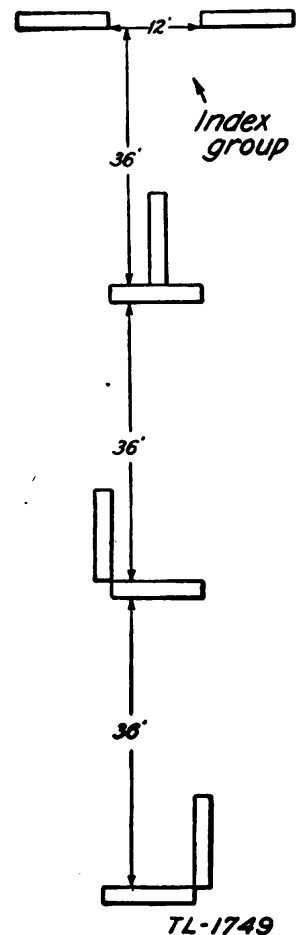
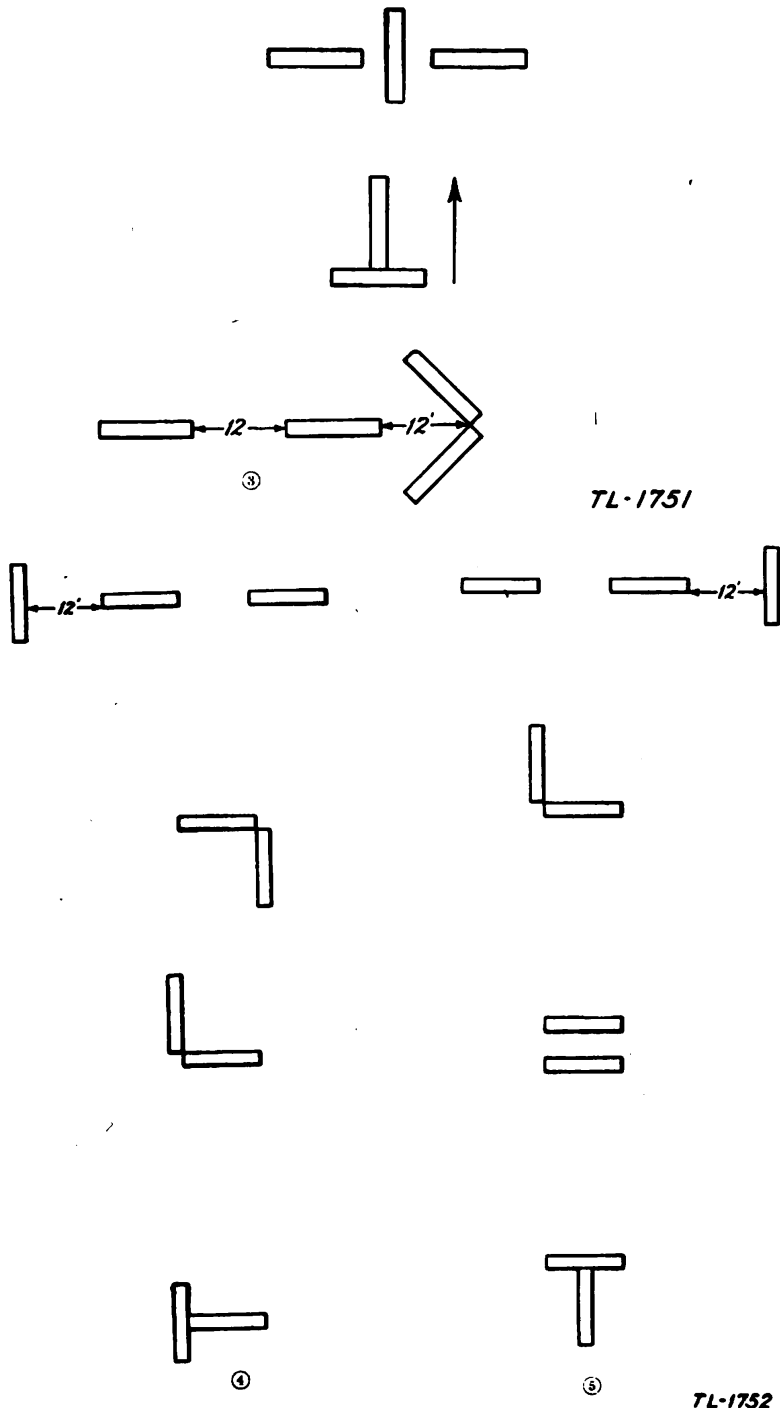


FIGURE 18.—Example of a code group, 182.

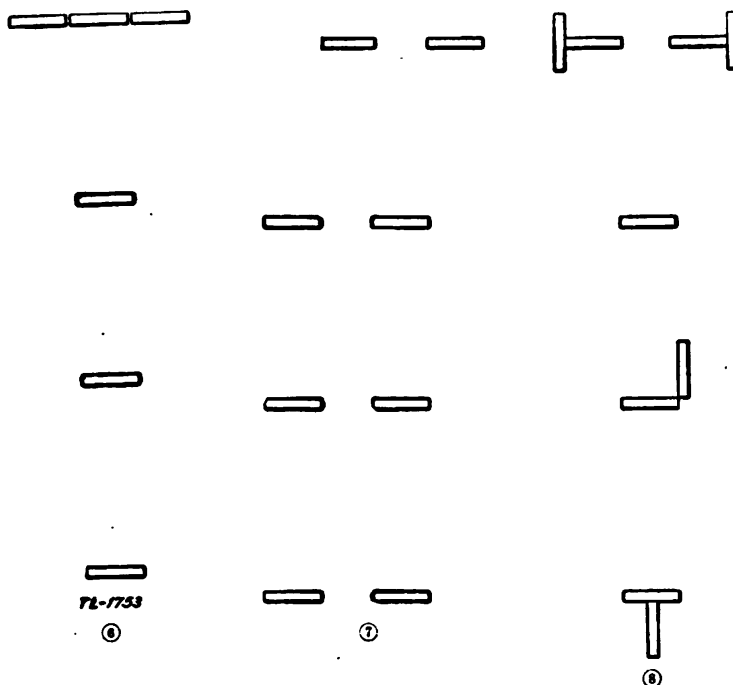
**Q.** Why are ground returns seldom used?—**A.** Because of interference due to earth currents, cross talk, and the possibility of the enemy listening in on such a system.



**For explanation of ①, ②, ③, ④, and ⑤ see opposite page.**

**FIGURE 19.—Special panel signals.**

**Q.** Describe briefly a phantom circuit.—**A.** A phantom circuit utilizes the two line wires connected to the line side of a repeating coil as one conductor of the phantom circuit, and the two lines similarly connected to another repeating coil as the other conductor. The connections from the phantom circuit are made to the center of the line side of the repeating coils. By use of this connection, no currents will be induced in the primaries of the repeating coils, and conversation may be carried on over the phantom circuit without disturbing or interfering with conversations over the normal, or side, circuits.



① Hostile plane near you.

② Wind direction.

③ In this direction.

④ Numerals are being displayed, 487.

⑤ Coordinates are being displayed, 895.

⑥ More to follow.

⑦ Error, cancel last display panels.

⑧ Reconnoiter 25 miles in the direction to be indicated by next display.

FIGURE 19.—Special panel signals—Continued.

**Q.** Describe briefly a simplex circuit.—**A.** A simplex circuit utilizes the two line wires connected to the line side of a repeating coil as one conductor of the simplex circuit. The return line is usually through the ground. The connection to the repeating coils is made to the center of the line side of the repeating coil winding. By use of this connection, no currents will be induced in the primaries of the repeating coils due to telegraph impulses in the secondaries, so that there will be no interference with conversation in the normal, or side circuit, due to telegraph impulses in the simplex circuit.

## SECTION II

### VISUAL SIGNALING—PANELS

|                              |              |
|------------------------------|--------------|
| Visual signaling—panels..... | Paragraph 50 |
|------------------------------|--------------|

**50. Visual signaling—panels.**—*Q.* What important visual signals are used in the military service?—*A.* Flags, panel signals, pyrotechnics, and signal lamps.

*Q.* For what are flags used?—*A.* For emergency communication between nearby troops.

*Q.* For what are pyrotechnics and signal lamps commonly used?—*A.* For transmission of messages to aircraft and ground troops, especially at night. Signal lamps are also used to challenge aircraft at night.

*Q.* For what are panel signals used?—*A.* For transmission of messages to friendly aircraft.

*Q.* How are panels classified? *A.*—

(1) Code panels.

(2) Marking panels.

*Q.* For what purpose are identification groups used?—*A.* To designate or identify military units, and the message-dropping grounds and panel display stations of such units.

*Q.* When are identification groups displayed?—*A.* When the ground troops wish to communicate with an approaching friendly plane. When not definitely needed they are taken in.

*Q.* What are code panels, and what size are they?—*A.* Code panels are strips of cloth. For ordinary communication they are 12 feet by 2 feet, 4 inches. For high-flying aircraft they are 30 by 6 feet.

*Q.* What panel codes are used? *A.*—

(1) Air-ground liaison code, which is subject to frequent change for purposes of safety.

(2) Fire-control code, which is standard. Operators of a panel section must memorize panel numerals in figure 17 for use in codes.

## SECTION III

### INSTALLATION OF FIELD TELEPHONE SYSTEM

|                                 |              |
|---------------------------------|--------------|
| General .....                   | Paragraph 51 |
| Installation.....               | 52           |
| Protection and concealment..... | 53           |

**51. General.**—*Q.* How are military wire circuits classed according to their use?—*A.* As trunk or local lines.

**Q.** What is a trunk line?—**A.** A line which connects two telephone switchboards or centrals.

**Q.** What is a local line?—**A.** A line which connects a switchboard to an individual telephone, or one between two individual telephones.

**Q.** How are wire circuits classed according to construction?—**A.** As metallic or grounded.

**Q.** What is the difference between the two?—**A.** In the metallic circuit two wires are used to provide a complete path for the current; in grounded circuits the earth replaces one wire.

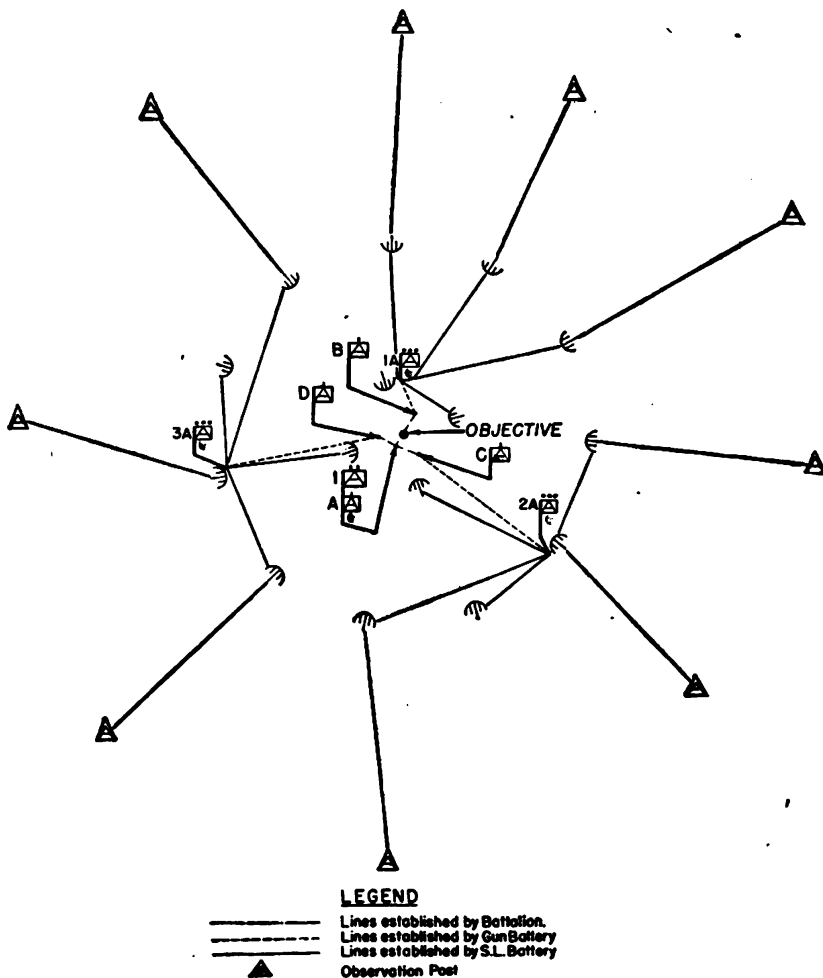


FIGURE 20.—Gun battalion telephone net.

**Q.** Are grounded circuits satisfactory? Why?—**A.** No, because of earth currents, cross talk, and the ease with which the enemy can pick up messages.

**Q.** What kinds of wire may be used?—**A.** Bare wire, insulated single-conductor, insulated twisted-pair, and cables may be used.

**52. Installation.**—**Q.** What kind of wire is generally used for antiaircraft artillery systems?—**A.** Twisted-pair, insulated, stranded field wire. Generally W-110 or W-110B wire is used.

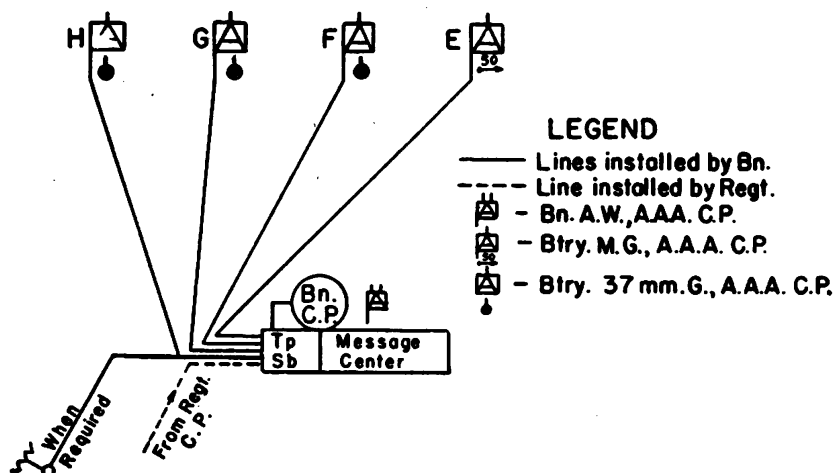


FIGURE 21.—Automatic weapons battalion telephone net.

*Q.* What is a line-route map?—*A.* A map showing the positions of all switchboards, test stations, and telephones; also the route taken by the line and the number of circuits. This is usually prepared as an overlay on a standard map.

*Q.* What is a circuit diagram?—*A.* An outline sketch showing all the circuits and their connections to each other and to the switchboards. Each circuit is given a number.

*Q.* In the case of wire lines between higher and lower units, who is responsible for their installation and maintenance?—*A.* The higher unit is responsible for wire communications from its command post to the command post of the next lower unit.

*Q.* What test should be made when laying the line?—*A.* Before the reels are taken out for laying wire, the wire should be tested for short and open circuits. For this purpose the wire on each reel should

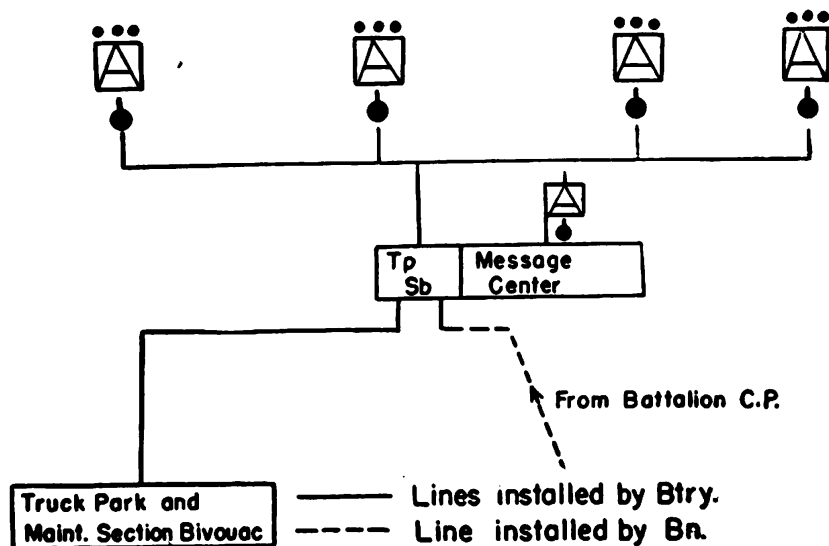


FIGURE 22.—37-mm gun battery telephone net.

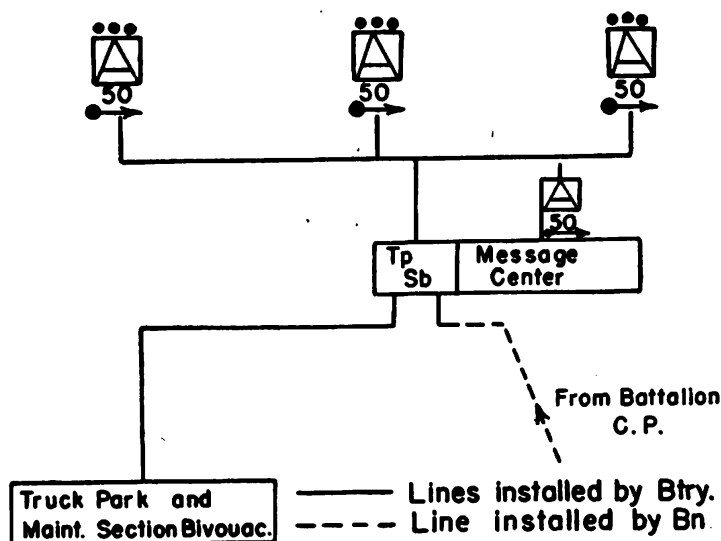


FIGURE 23.—Machine-gun battery telephone net.

be continuous and have the ends exposed. Then as the lines are payed out they should be tested back to the starting point every quarter mile and at every splice made.

*Q.* How should lines cross a road?—*A.* Through a culvert, ditch, or high enough to be clear of all traffic.

*Q.* Should there be any slack when wire is laid? Why?—*A.* Wire should be laid slack so breaks can be repaired and small pieces cut out if necessary.

*Q.* How are lines laid across water?—*A.* Use a single section of weatherproof wire in good condition and weight it sufficiently to hold it against the movement of the current.

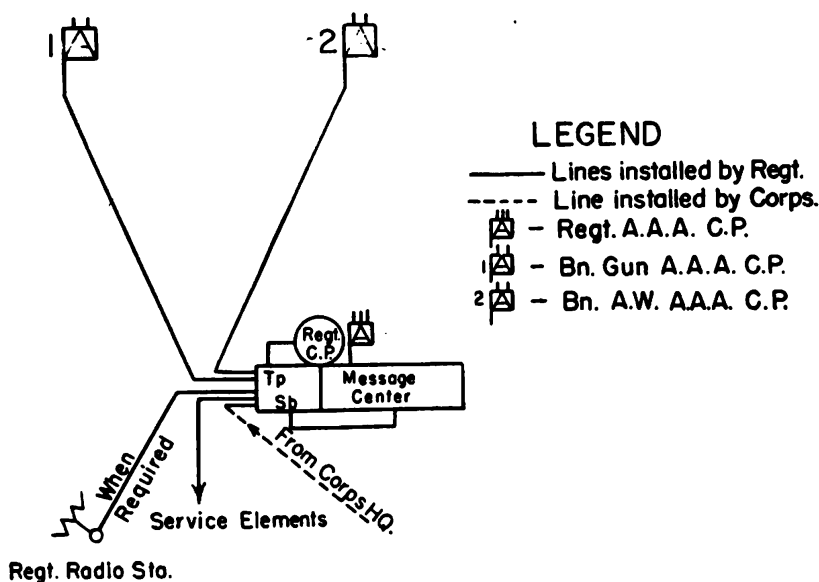


FIGURE 24.—Regimental telephone net.

**Q.** What provision is made to maintain communication should a line be broken by shell fire or other causes?—**A.** Duplicate lines are run, whenever possible, by different routes, to distant and important OP's or CP's which are connected to the switchboard and thus readily substituted for defective lines.

**Q.** What is "short-stake construction"?—**A.** Short stakes about 4½ feet in length are driven into the ground at intervals of about 15 to 20 feet. Small insulated knobs, usually of wood or poreclain, are fastened to the stakes. Wires are attached to these knobs.

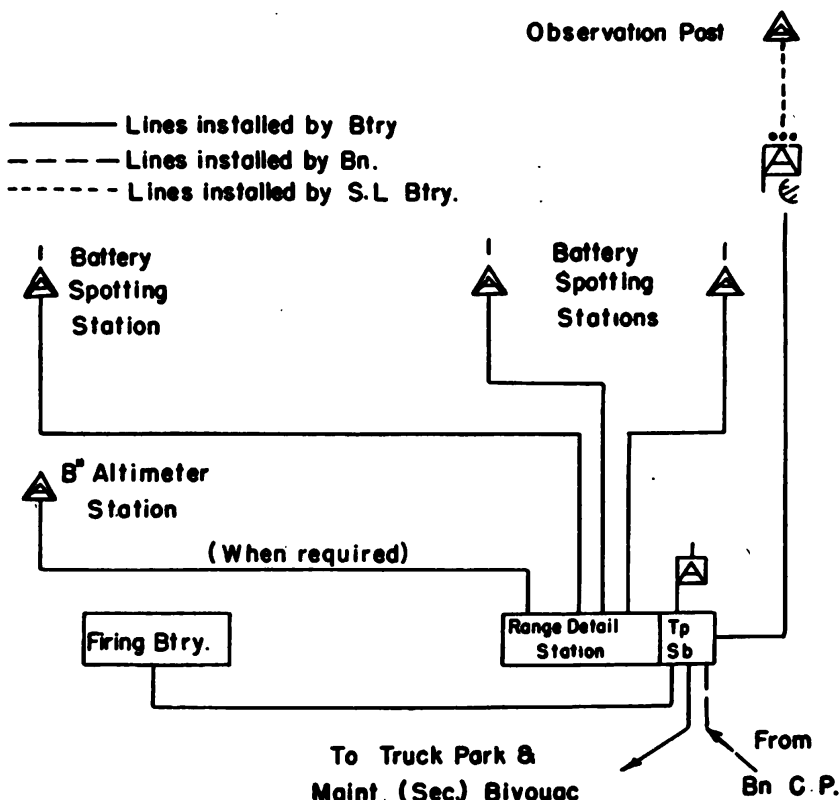


FIGURE 25.—Gun battery telephone net.

**Q.** What is "wire trench construction"?—**A.** Short stakes are driven into the bottom of a small wire trench at intervals of about 8 to 10 feet, and wire attached as in the preceding case.

The candidate should be required to draw a sketch and describe a typical telephone installation such as shown in figures 20 to 26, inclusive, indicating the lines that are laid by various units. He should also be required to demonstrate practically, as far as possible, his ability to set up the telephone net required by his unit.

**53. Protection and concealment.**—**Q.** What would be a good telephone position?—**A.** One free from enemy observation and protected from shell fire. It should not be necessary for the operator

to lie down, nor should he be in a position where he is subject to repeated interruption because of the physical movement and conversation of others.

*Q.* Where should the switchboard be placed?—*A.* At some quiet spot, centrally located, well protected from shell fire.

*Q.* Give some points to be observed in selecting a route for a telephone line.—*A.* It should—

- (1) Be as short as possible.

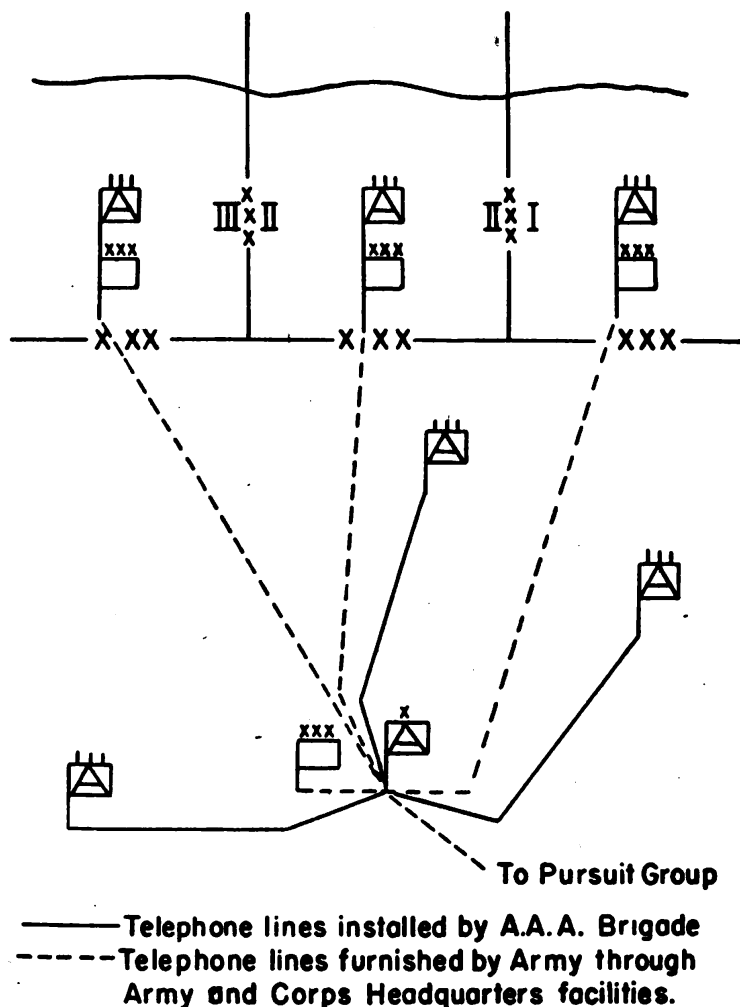


FIGURE 26.—Wire communication of an antiaircraft brigade in an army area.

- (2) Avoid main lines of travel.
- (3) Avoid road junctions.
- (4) Follow some natural line of concealment.
- (5) If in view of the enemy, be camouflaged.
- (6) Avoid areas within range of hostile light artillery, where possible.

*Q.* What natural features can be utilized in laying a line?—*A.* Reverse slopes of hills, trenches, ditches, and woods.

*Q.* How are telephones and operators protected?—*A.* Normally OP's are carefully concealed by camouflage and, if time permits, provided with some cover.

## SECTION IV

## LOCATION OF FAULTS; TESTS FOR GROUNDS AND SHORT CIRCUITS

Paragraph

Location of faults; tests for grounds and short circuits..... 54

**54. Location of faults; tests for grounds and short circuits.—**

*Q.* How is a telephone tested to determine if it is in serviceable condition? *A.*—

(1) *Ringin*g circuit.—Crank the magneto and note the amount of effort required. Short circuit the line terminals with a wire and again crank the magneto. If the ringing circuit is in order, the effort required in the latter case will be much greater.

(2) *Transmitting and receiving circuits, and strength of battery.*—Place the receiver to the ear and short circuit the terminals with a short piece of wire or other metal. Press the button several times and if there is a strong click in the receiver each time the button is released, the circuit and the battery are in good order. A weak click indicates a poor battery. Another test is to short circuit the line terminals and blow in the transmitter. The blowing sound should be plainly heard in the receiver if the battery and circuits are in good order.

*Q.* What test may be made for a broken cord?—*A.* One method is to short circuit the line terminals and work the cord up and down, while holding the transmitter button closed. A clicking sound indicates a broken cord. In case the cord has been broken by pulling on it, or if both wires in the cord are broken, the above test may not work, in which case it would be necessary to remove the cord and connect each wire separately between L1 and L2 on the test set. If the voltmeter shows a deflection when key No. 3 is removed to the lower position, the cord is good. While this test is being made, it is advisable to move the cord to be sure the wire is not making a momentary contact.

*Q.* What may be the trouble if it is impossible to ring a distant station? *A.*—

(1) Broken wire or a loose connection in the ringing circuit of the telephone or distant telephone.

(2) Unserviceable magneto in telephone.

(3) Unserviceable buzzer in the distant telephone.

(4) Open, shorted, or grounded wires in the line between telephones.

*Q.* What may be the trouble if it is possible to receive but not to transmit? *A.*—

- (1) Transmitter may be unserviceable.
- (2) Receiver in distant telephone may be unserviceable.
- (3) Transmitter cord in telephone may be unserviceable.
- (4) Distant receiver cord may be broken.
- (5) Thumb switch button on handset may be out of order, and not making proper contact.
- (6) Battery may be deteriorated.

*Q.* What may be the trouble if it is possible to transmit but not to receive? *A.*—

- (1) Receiver may be unserviceable.
- (2) Transmitter in distant telephone may be unserviceable.
- (3) Receiver cord may be broken.

*Q.* What is the purpose of the universal test set?—*A.* To test field wire circuits and locate troubles.

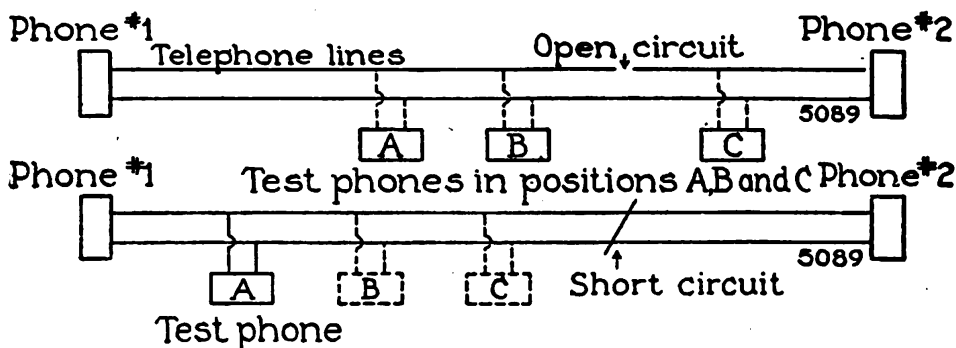


FIGURE 27.— Above: Test for open circuit. Below: Test for short circuit.

*Q.* Explain the tests indicated by figure 27.—*A.* Test No. 1 shows how an open line is located. At positions *A* and *B* the tester can talk to telephone No. 1. At position *C* the tester cannot talk to telephone No. 1 but can talk to telephone No. 2, therefore the open line must lie between positions *B* and *C*. Test No. 2 shows how the approximate location of a short circuit may be obtained. As the tester moves from position *A* toward the short circuit, conversation with telephone No. 1 becomes more and more difficult. Depending on the type of line and the character of the short circuit, this test may or may not be possible of satisfactory accomplishment.

*Q.* What tests can be made with this set? *A.*—

- (1) Ringing substation or party.
- (2) Talking to substation or party.
- (3) Test for short circuits.
- (4) Test for grounds.
- (5) Test for crosses on lines carrying current.
- (6) Test for crosses on other lines.

(7) Measuring voltage of auxiliary batteries.

*Q.* What batteries are required for this set?—*A.* One type BA-1 for energizing the transmitter, and two type BA-2 in series for the voltmeter.

*Q.* How should the keys be set to ring?—*A.* Key No. 1 set to “ring,” all others neutral.

*Q.* How should the keys be set to test for shorts?—*A.* Key No. 3 should be thrown to the lower position “VMB,” and the reading on the voltmeter noted. If a reading appears it shows a short. The full battery voltage indicates a dead short.

*Q.* How should the keys be set for talking or listening?—*A.* Key No. 1 set to “listen.”

*Q.* How should the keys be set for ground tests?—*A.* Key No. 3 should be thrown to upper position “VMG”; this tests one side of the line for grounds. Leaving No. 3 in that position, throw key No. 2 to “LR” position, which reverses the line and tests the other side for grounds. Any reading on voltmeter shows a ground. Full battery voltage shows a direct ground.

## SECTION V

### INSTALLATION AND OPERATION OF MESSAGE CENTERS; ENCODING AND DECODING

|                            | Paragraph |
|----------------------------|-----------|
| Message centers.....       | 55        |
| Encoding and decoding..... | 56        |

**55. Message centers.**—*Q.* What is the purpose of a message center?—*A.* To receive, transmit, or deliver all messages except the following:

(1) Messages transmitted directly from the originator to addressee by telephone or messenger.

(2) Messages handled by postal service.

(3) Messages passing directly from the originator to a signal communication agency (such as a radio station) for immediate transmission, in cases authorized by the commander.

*Q.* Where is the message center located?—*A.* At or near the command post of the unit it serves.

*Q.* What signal agencies are available to a message center?—*A.* All established agencies; radio, telephone, messenger, and visual agencies are usually established.

*Q.* With respect to priority, how are messages classified? *A.*—

(1) Urgent messages (O).

(2) Priority messages (P).

(3) Routine messages (no symbol).

**Q.** What is an urgent message?—**A.** One where delay may result in unnecessary casualties or serious tactical disadvantages. This type of message is sent immediately upon receipt.

**Q.** What is a priority message?—**A.** One of such importance or urgency that it is given precedence over routine messages.

**Q.** What is a routine message?—**A.** One which requires no priority. Such messages are generally sent in the order in which filed.

**Q.** Who designates the means to be used for transmitting any message?—**A.** The message center chief selects the most suitable means available for the transmission of any message.

**Q.** May the originator make this designation?—**A.** The originator does not ordinarily designate the means used but if he desires it to go by messenger, he may so mark it and it will be delivered that way.

**Q.** What records are kept at a message center?—**A.** A register showing times of receipt, dispatch, and delivery of every message. This record also shows the routing, to whom sent, and the means of transmission.

**Q.** If a messenger service is established, who operates it and how is it coordinated with those of other units?—**A.** The messenger service is operated by the message center. Subordinate units time their service to agree with that of higher units.

**56. Encoding and decoding.**—**Q.** What is a code?—**A.** A method of secret writing in which groups of symbols are substituted for sentences, phrases, words, letters, or numbers. To use a code, a complete list of groups of symbols and their meanings must first be prepared.

**Q.** What is a cipher?—**A.** A method of secret writing in which the letters in a message are transposed, or other letters or numbers are substituted for the letters in a message, according to a prearranged key. A mechanical device is often used for enciphering and deciphering messages.

**Q.** When are messages put in cipher or code?—**A.** All messages transmitted by radio or other means which might be intercepted by the enemy are put in code or cipher except, when in the opinion of the commander, the information contained therein is of no value to the enemy or when its urgency outweighs its value to the enemy. Such messages are marked "Send in clear" over the commander's signature.

**Q.** Give some rules to be observed in the use of codes and ciphers.  
**A.**—

- (1) Never encode a message unless it is necessary.
- (2) Never encode a message that has already been sent in the clear.
- (3) Make coded message short.
- (4) Never use coded and uncoded words in the same message.

**Q.** Describe the cipher device type M-94.—**A.** This device consists of a shaft upon which are placed 26 aluminum disks, each of which has a series of slots and projections for engaging the adjacent disks. Twenty-five of the disks show upon their rims the alphabet differently arranged, while the twenty-sixth carries a guide rule which may be revolved about the assembled cylinder and brought under any one of the 26 horizontal lines of letters. The disks are assembled on the shaft and held in place by a thumb nut.

**Q.** It is necessary to place the disks on the shafts in any particular order?—**A.** Yes. This is the way in which the key is employed.

**Q.** How is this order determined?—**A.** Assume that the key phrase "United States of America" has been designated.

(1) Write the numbers from 1 to 25, inclusive, on a horizontal line.

(2) Under these numbers, write the letters of the key word or phrase, repeating if necessary, until a letter is beneath each number.

|           |    |    |    |    |   |   |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
|-----------|----|----|----|----|---|---|----|----|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| (1) ..... | 1  | 2  | 3  | 4  | 5 | 6 | 7  | 8  | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| (2) ..... | U  | N  | I  | T  | E | D | S  | T  | A | T  | E  | S  | O  | F  | A  | M  | E  | R  | I  | C  | A  | U  | N  | I  | T  |
| (3) ..... | 24 | 14 | 10 | 20 | 6 | 5 | 18 | 21 | 1 | 22 | 7  | 19 | 16 | 9  | 2  | 13 | 8  | 17 | 11 | 4  | 3  | 25 | 15 | 12 | 23 |

(3) Place numbers under the letters, from left to right in accordance with their relative position in the alphabet. Thus, under the first A, place 1; under the second A, 2; and under the third A, 3. Since B does not appear in the key phrase, C is the next letter considered, the number 4 being placed beneath it. Continue in a like manner until a number is written beneath each of the 25 letters of the key phrase. The last number should be 25: if not, an error has been made.

(4) The numbers in the bottom line determine the order in which the disks are assembled on the shaft. Thus, with the key phrase used in this example, disk No. 24 is placed on the shaft first; then No. 14; and so on, in order, with the last disk being No. 23.

**Q.** How is a message enciphered?—**A.** After placing the disks on the shaft in the correct order as determined by the key word or phrase, revolve the disks one by one until the first 25 letters of the message are arranged in order from left to right on a horizontal line just above the guide rule. Disengage the guide rule disk so that it may revolve and set it under any one of the other 25 horizontal lines of letters. Write, in groups of 5 letters each, the letters appearing immediately above the rule. This will be the cipher equivalent.

lent of the first 25 letters of the message. The remainder of the message is enciphered in the same manner.

*Q.* Where is the cipher device used?—*A.* At the message center.

*Q.* How is a message deciphered?—*A.* Knowing the key word or phrase and having arranged the disks in their proper order, set up the first 25 letters of the cipher message in order from left to right on a horizontal line just above the guide rule. Revolve the guide rule slowly, looking for a line with an intelligible text of the first 25 letters of the message. The remainder of the message is deciphered in the same manner.

## SECTION VI

### LINEMEN AND TELEPHONE AND SWITCHBOARD OPERATORS

|  |              |
|--|--------------|
| Lineman and telephone and switchboard operators..... | Paragraph 57 |
|--|--------------|

**57. Linemen and telephone and switchboard operators.**—The candidate should be required to demonstrate practically his ability to instruct linemen and telephone and switchboard operators. Duties of linemen and of telephone and switchboard operators are outlined in TM 4-325 and 4-330.

## SECTION VII

### DISSEMINATION OF ALARMS; RECORDS AND REPORTS

|                          |              |
|--------------------------|--------------|
| Flash messages .....     | Paragraph 58 |
| Records and reports..... | 59           |

**58. Flash messages.**—*Q.* From what sources do antiaircraft artillery intelligence alarms come?—*A.* From the observers of the antiaircraft regiment, from adjacent and higher units, and from the aircraft warning service.

*Q.* In what form are these messages sent?—*A.* As flash messages.

*Q.* For what purpose are they sent?—*A.* To alert the batteries of the regiment upon the approach of enemy aircraft.

*Q.* Explain the uses of the gun battery observation posts.—*A.* They are located one on each side of the gun battery and are primarily spotting stations, but also possible sources of flash messages.

*Q.* Who establishes the outer ring of observation posts?—*A.* The various batteries of the regiment, under the direction of the regimental commander. He designates the number and general location of these posts and assigns their installation to such batteries as are best able to install and maintain them.

**Q.** How do personnel in observation posts normally send in flash messages?—**A.** They use field telephones.

**Q.** To what units are their telephone lines connected?—**A.** They are connected to the nearest installations. Usually they are connected into the searchlight platoon net at one of the forward lights. They may in some cases connect to a gun or machine-gun battery switchboard.

**Q.** When an observer sends in a flash message, how is it routed?—**A.** It is picked up by the platoon or battery operator who, during daylight hours, connects the observer with the proper gun battery immediately. At night, the searchlights nearest the approaching aircraft are connected first. The message is relayed to the gun battalion and thence to the regimental message center. These two will give further proper distribution to the message.

**Q.** When an observer can only partially identify an enemy formation, what report should he make?—**A.** He should send a partial flash message and complete it later when he can secure more information. It is a general rule that partial, prompt information is more valuable than delayed, complete information.

**Q.** Are flash messages sent to higher headquarters?—**A.** They are not sent as such. The intelligence officer may order that the information contained in them be sent to neighboring antiaircraft regiments, to higher headquarters, or to friendly Army Air Force troops. In the same manner, such information may be received from higher headquarters and the intelligence officer may order it sent out as a flash message.

**Q.** What information is contained in a flash message?—**A.** See following form.

#### FORM FOR FLASH MESSAGE (A. A. A. I. S.)

Serial No. \_\_\_\_\_ Date \_\_\_\_\_ Organization \_\_\_\_\_  
Time sent \_\_\_\_\_ To \_\_\_\_\_ How sent \_\_\_\_\_

| Observation post<br>1 | Number of airplanes<br>2 | Type of airplanes<br>3 | Time seen or heard<br>4 | Altitude<br>5 | Sector in which flying<br>6 | Direction of flight<br>7            |
|-----------------------|--------------------------|------------------------|-------------------------|---------------|-----------------------------|-------------------------------------|
| OP—                   | One—                     | Heavy bombardment.     | —                       | Very low      | —                           | North.                              |
|                       | Two—                     | Observation—           | —                       | Low           | —                           | Northeast.                          |
|                       | Three—                   | Pursuit—               | —                       | Medium        | —                           | East.                               |
|                       |                          | Light bombardment.     | —                       | High          | —                           | Southeast.                          |
|                       | Several—                 | Airplane—              | —                       | —             | —                           | South.                              |
|                       | Many—                    | —                      | —                       | —             | —                           | { Southwest.<br>West.<br>Northwest. |

**NOTE.**—Very low—below 500 yards; low—500 to 2,000 yards; medium—2,000 to 4,000 yards; high—above 4,000 yards.

Both sender and receiver check off items where possible and save time.

**59. Records and reports.**—*Q.* What record is made of flash messages?—*A.* The sender and all operators receiving it record it, usually by checking appropriate words on a flash message form.

*Q.* What files of antiaircraft artillery intelligence reports are kept at regimental headquarters?—*A.* The intelligence officer has a file of

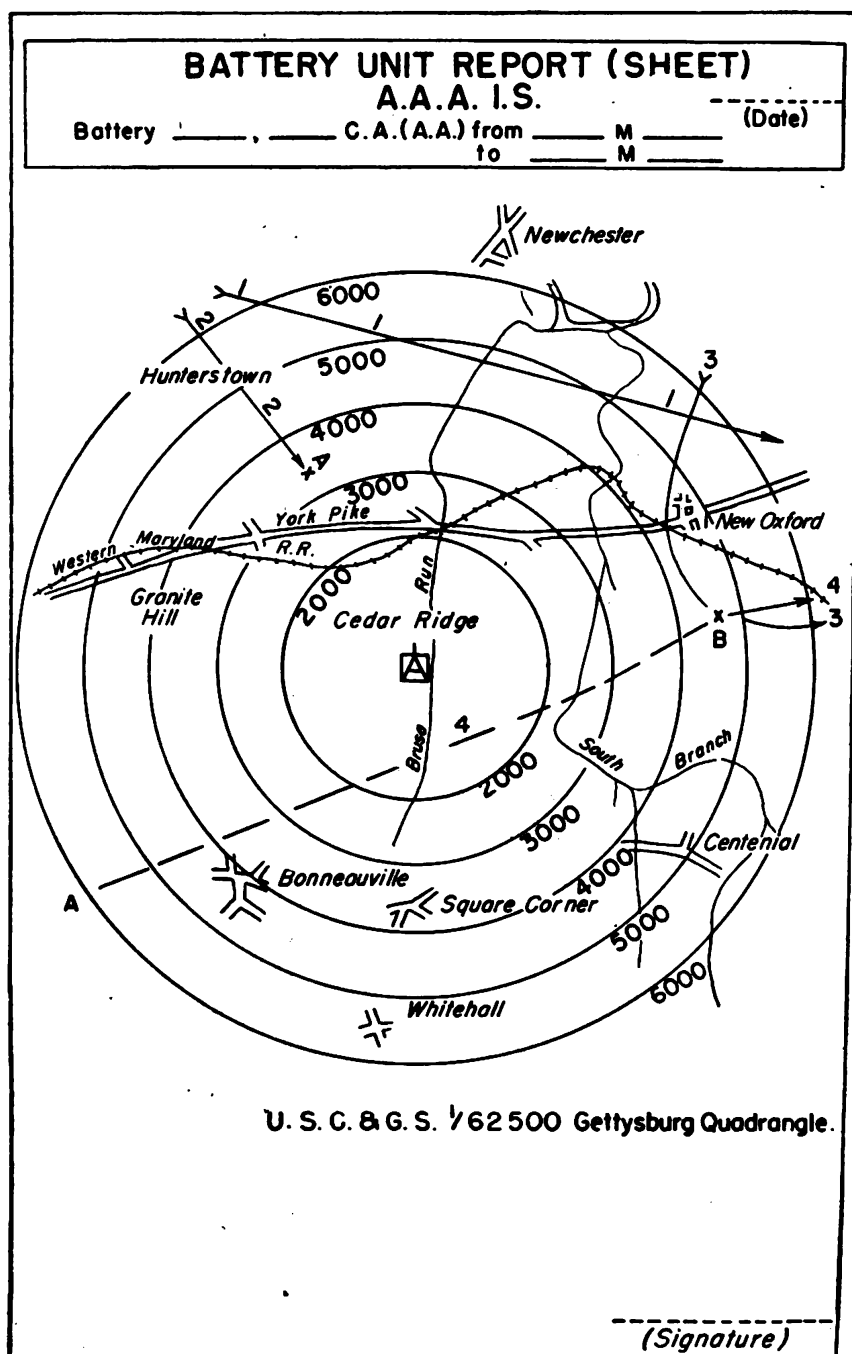


FIGURE 28.—Battery unit report (graphical).

battery unit reports for use in preparing his daily intelligence report for higher headquarters. He also maintains other files of data required for his periodic reports.

### BATTERY UNIT REPORT (TABULAR) (A. A. A. I. S.)

-----  
(Date)

From -----

Battery -----

To -----

| Serial<br>number<br>of flight<br>crossing<br>area | Time of—      |                | Description |             |                    | Altitude<br>(yards) |              | Rounds fired | Remarks  |
|---|---------------|----------------|-------------|-------------|--------------------|---------------------|--------------|--------------|--|
|   | Arrival       | Depart-<br>ure | Formation   | Num-<br>ber | Type               | Maxi-<br>mum        | Mini-<br>mum |              |  |
| 1 -----   | a.m.<br>10:28 | a.m.<br>10:31  | Closed V    | 9           | Pursuit -----      | 3,500               | 3,500        | 12           | Intermittent clouds ob-<br>scured target.  |
| 2 -----   | 11:03         | 11:05          | -----       | 1           | Reconnaissance     | 3,200               | 3,200        | 16           | Shot down at A, Battery<br>C firing on same target<br>at same time.  |
| 3 -----   | 11:21         | 11:28          | Closed V    | 9           | Pursuit -----      | 3,800               | 3,000        | -----        | Apparently same forma-<br>tion as 1. Attacked by<br>7 PW-8's at B with re-<br>sult 2 (type) pursuits<br>fell in flames. Remain-<br>der lost in clouds. |
| 4 -----   | 11:20         | 11:30          | Open V      | 7           | Pursuit (friendly) | 4,500               | 3,000        | -----        | See remarks under 3.   |

-----  
(Signature)

Q. Who assists the intelligence officer in preparing intelligence reports?—A. He is assisted by clerks detailed from the headquarters battery.

## CHAPTER 4

### OBSERVATION AND POSITION FINDING

|  | Paragraphs |
|--|------------|
| <b>SECTION I. Position-finding system</b> -----  | 60         |
| II. Position-finding apparatus-----              | 61-66      |
| III. Observation and adjustment of fire-----     | 67-69      |
| IV. Orientation—use of transit-----              | 70-72      |
| V. Indication and identification of targets----- | 73-77      |
| VI. General duties of observers-----             | 78         |
| VII. Operation of antiaircraft spotting set----- | 79-85      |
| VIII. Operation of meteorological section-----   | 86-89      |

#### SECTION I

#### POSITION-FINDING SYSTEM

|                                      | Paragraph |
|--------------------------------------|-----------|
| <b>Position-finding system</b> ----- | 60        |

**60. Position-finding system.**—*Q.* What is meant by position finding?—*A.* Position finding is the process of determining the position in space of a target with reference to the battery, and the prediction of its future position.

*Q.* How is the position of a target with reference to the battery determined?—*A.* By measuring the azimuth and angular height to the target and its altitude. These three elements establish the exact position of the target in space.

*Q.* What instrument is used in the (candidate's) battery to determine altitude?—*A.* A stereoscopic height finder; M1920 altimeters may be used in an emergency.

*Q.* The altitude having been determined, what use is made of it?—*A.* It is set into the director.

*Q.* How is this information sent to the director?—*A.* Either by telephone or by an altitude transmitter on the height finder and a receiver in the director.

*Q.* When using altimeters what special preparation is necessary that is not required when using the height finder?—*A.* A base line must be laid out and measured.

*Q.* What two systems are used by directors in computing firing data?—*A.* The angular travel method and the linear speed method.

*Q.* What system is used by the director in your battery?—*A.* -----

*Q.* How are corrections for wind and drift made on the later types of directors?—*A.* Corrections for wind and drift are made automatically by the director.

Q. What data must be set into the director before it can correct for wind and drift?—A. The velocity and azimuth of the ballistic wind furnished by the meteorological message. Correction for drift is fully automatic.

Q. What is the basis of the angular travel method used in the determination of the future position of the target?—A. The measurement of

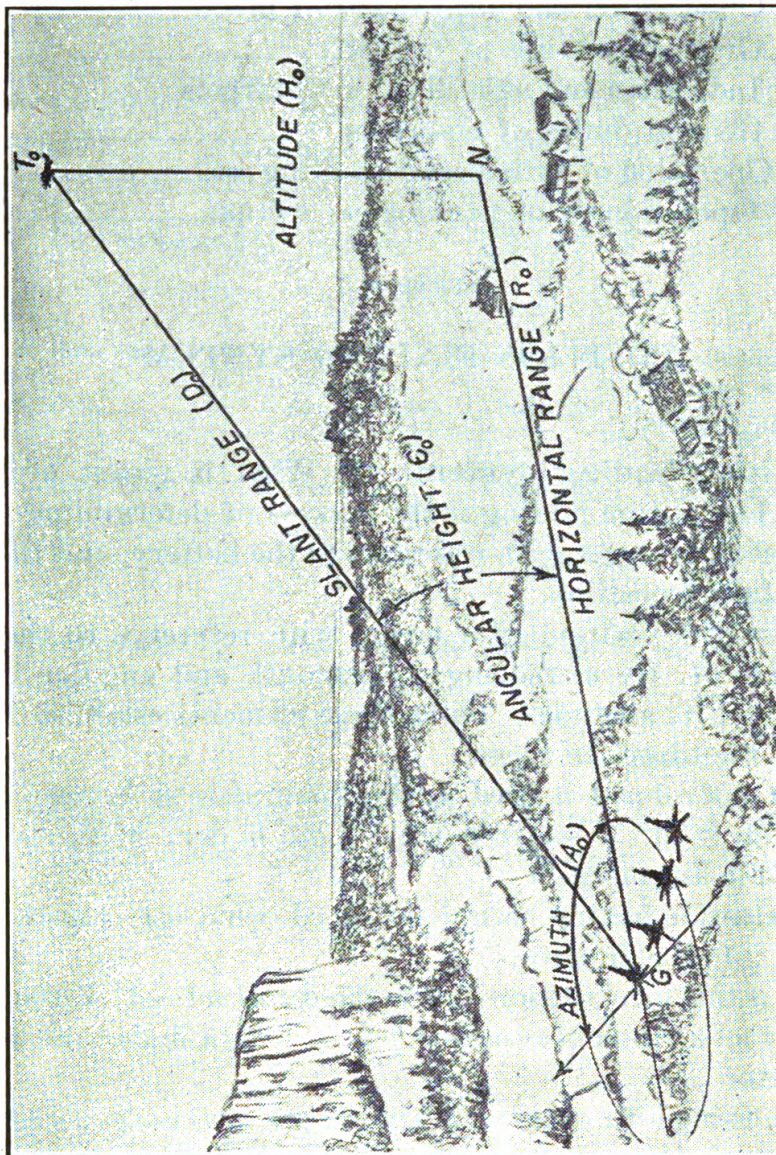


FIGURE 29.—Location of an airplane target; present position ( $T_0$ ).

the instantaneous angular speed of the target in azimuth and in elevation, and the multiplication of these quantities by the time of flight of the projectile in order to determine the future position.

Q. What is the basis of the linear speed method used in the determination of the future position of the target?—A. The determination of the direction of flight and ground speed of the target, and the

multiplication of the ground speed by the time of flight of the projectile to determine the future position.

Q. What emergency system of position finding is available to the (candidate's) battery?—A. -----.

## SECTION II

### POSITION-FINDING APPARATUS

|                                    | Paragraph |
|------------------------------------|-----------|
| Stereoscopic height finder M1----- | 61        |
| Stereoscopic height finder M2----- | 62        |
| Check of height finder-----        | 63        |
| Altimeter M1920-----               | 64        |
| Director M4-----                   | 65        |
| Directors M3 and M3A1-----         | 66        |

**61. Stereoscopic height finder M1.**—Q. What are the general characteristics of the stereoscopic height finder M1? A.—

Type----- Self contained (stereoscopic).

Base----- 4 meters (13.5 feet).

Magnification----- 12 and 24 power.

Range scale----- 550 to 50,000 yards.

Transmitter----- 0 to 10,000 yards.

Elevation----- 0° to 90°.

Traverse----- 360°.

Tracking telescopes:

Magnification----- 8 power.

Field----- 6°.

Weight of component parts:

Tube----- 575 pounds.

Cradle----- 160 pounds.

Tripod----- 185 pounds.

Weight of unit packed, 2,160 pounds.

Q. Describe briefly the main structural elements of the tube of the instrument.—A. The main structural elements are two concentric tubes: a double-walled body tube and an optical tube or bar.

(1) The body tube consists of an inner and outer tube of such diameters that there is a space between them. This space, sealed at the ends, forms an air chamber which acts as an insulator against heat, preventing sudden changes in temperature from affecting the accuracy of the instrument.

(2) The outer tube constitutes the base of, and serves as a cover or housing for, the instrument proper. It is supported on the cradle by two ball-bearing surfaces, one on each side of the center of the tube, allowing it to rotate freely in elevation. This outer tube car-

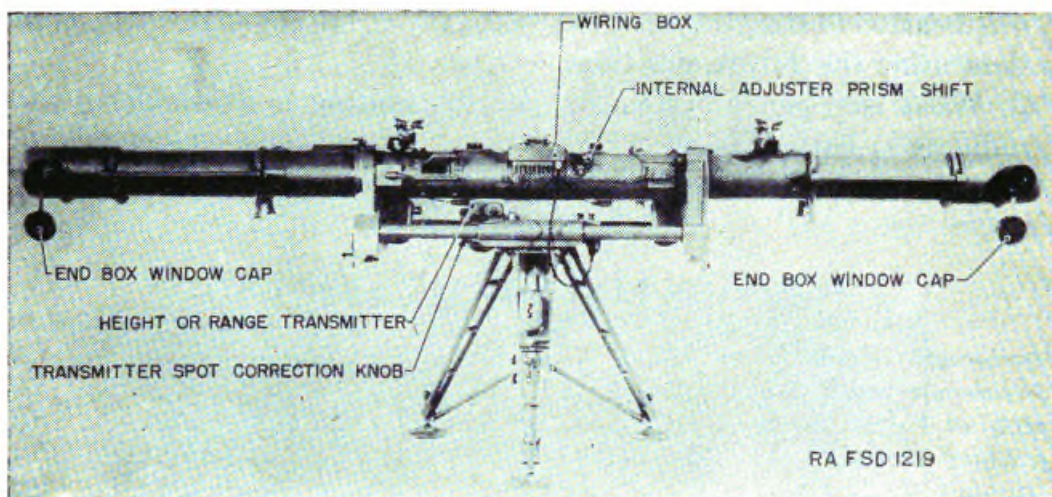


FIGURE 30.—Height finder M1, front view.

ries the end windows, the eyepiece unit, and other units which are not sensitive optical parts of the instrument.

(3) The inner or main tube has attached to it the end reflectors, compensator (measuring wedges), correction plate for height of image adjustment, and the internal adjuster system. This main tube is suspended in the outer tube at two places.

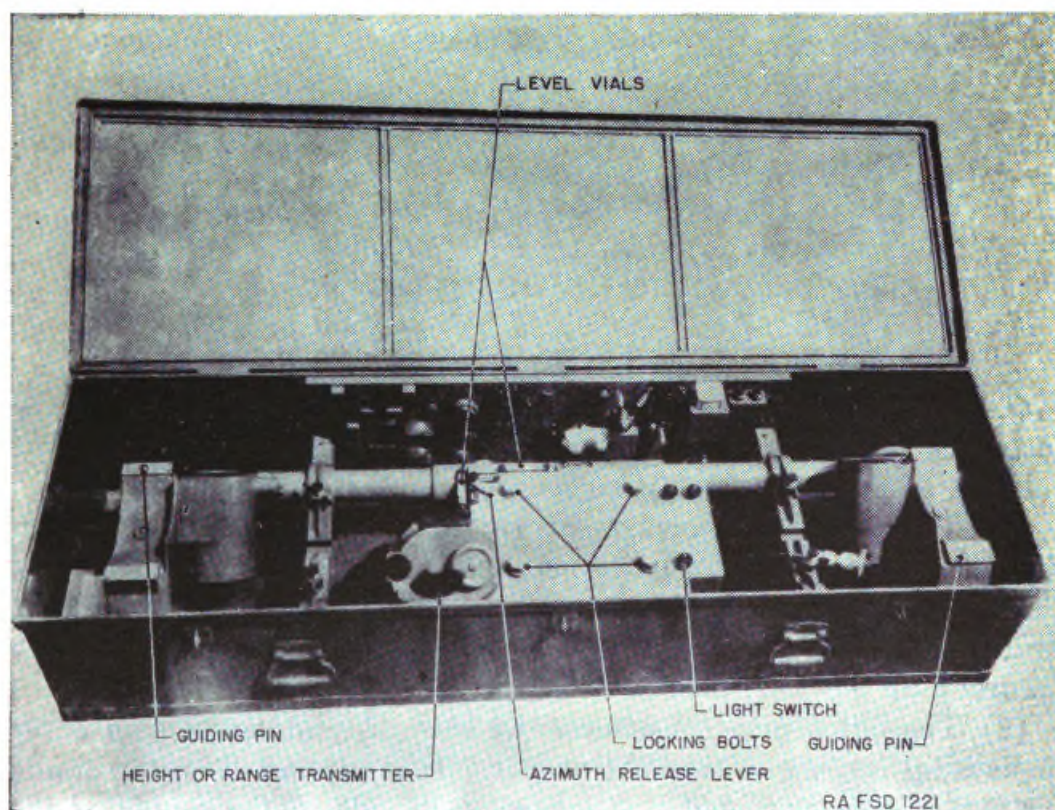


FIGURE 31.—Packing chest for cradle, tools, and spare parts.

(4) The optical tube or bar carries the objective lenses, reticles, erecting system, and central prisms. These parts are the most sensitive optical parts of the instrument. The optical bar is made of especially treated steel, is perfectly balanced, and is supported by the inner or main tube.

Q. What are the steps in setting up the height finder? A.—

(1) *Tripod*.—(a) Choose or prepare an approximately level site of an area that will allow the legs of the tripod to be spread to the mechanical limit. This insures maximum stability.

(b) Spread the legs and clamp the sleeve on the tripod pivot arm firmly in place.

(c) Roughly level the tripod by eye, by adjusting the ground plates with the wrench provided.

(2) *Cradle*.—(a) Upon removal of the cradle from its packing case, set the release lever at the release index. This action releases the azimuth gears.

(b) Two men lift the cradle and carefully set it in position on the tripod head so that the locking bolts engage in their respective holes in the tripod head housing.

(c) Run down the locking bolts snugly with the wrench provided.

(d) Turn the azimuth release lever to the engaged position.

(3) *Tube*.—(a) Check the reading of the elevation receiver on the cradle and set it to zero if not so positioned.

(b) Check the elevation index with the zero line on the tube. If they do not match, the elevation drive can be turned with the fingers where it meshes with the elevation drive of the cradle until the elevation index and the zero line of the tube do match.

(c) Eight men lift the tube by means of the porter bars and carefully set it in the cradle.

(d) After accurate seating, the locking knobs are turned until tube is locked in position.

(4) *General*.—(a) Level the instrument accurately by use of the level vials on the cradle and adjustment of the ground plates of the tripod.

(b) Check the level and readjust until the instrument is level throughout its traverse.

(c) Plug in the data transmission system.

(d) Engage the plug of the lighting circuit with the socket on the cradle.

(e) Turn the light switch to the proper setting, depending upon the source of power.

(f) Check the lighting fixtures for operation.

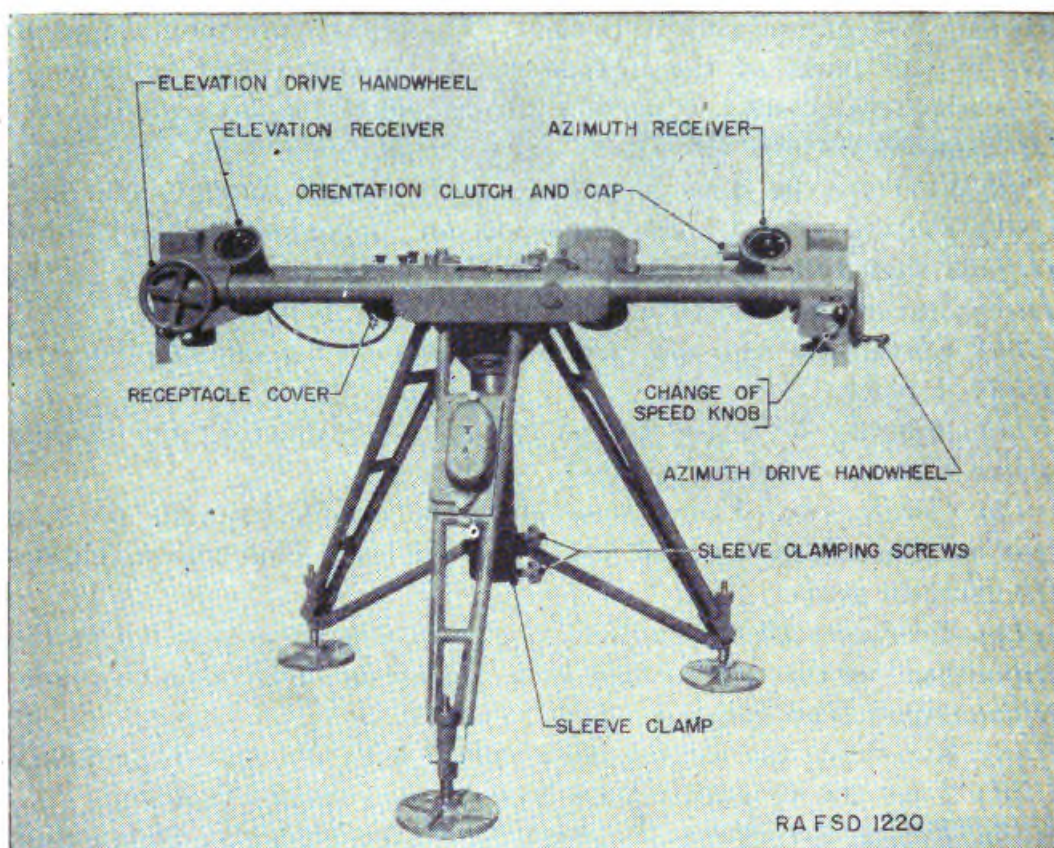


FIGURE 32.—Tripod and cradle for height finder M1.

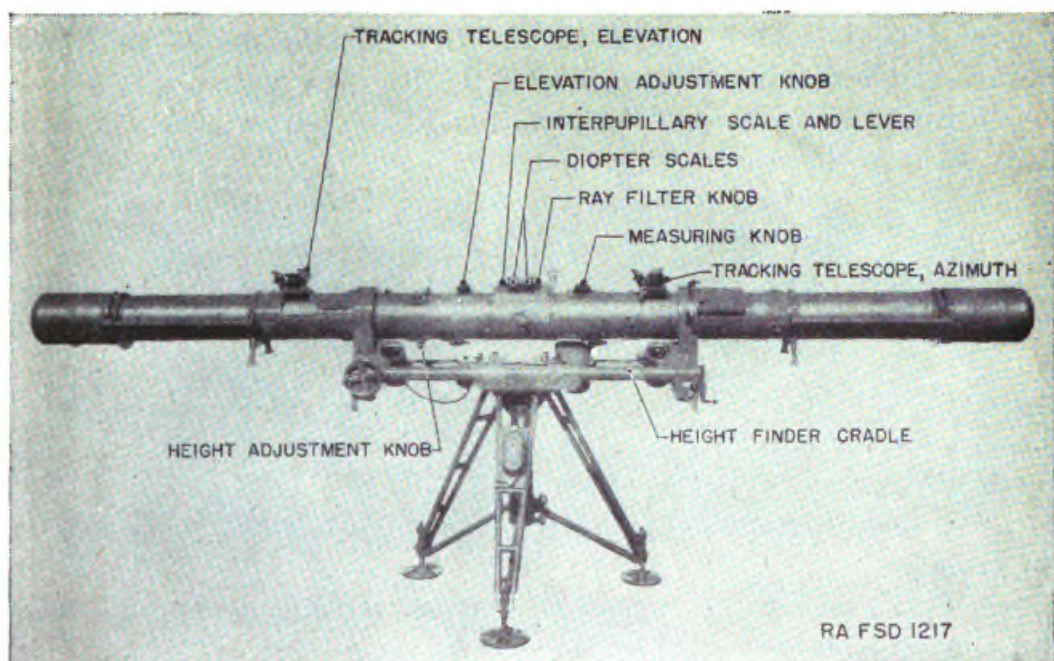


FIGURE 33.—Height finder M1, rear view.

Q. How is the height finder oriented? A.—

(1) *Azimuth*.—(a) Level the instrument.

(b) Traverse the height finder until the center symbol of the stereoscopic observer's reticle is accurately centered on the reference point or orienting mark.

(c) Hold the height finder stationary. Unscrew the dust cap of the orienting clutch. Turn the orienting clutch until the mechanical (outer) dial of the height finder azimuth receiver indicates the azimuth of the datum point from the height finder. Move the instrument

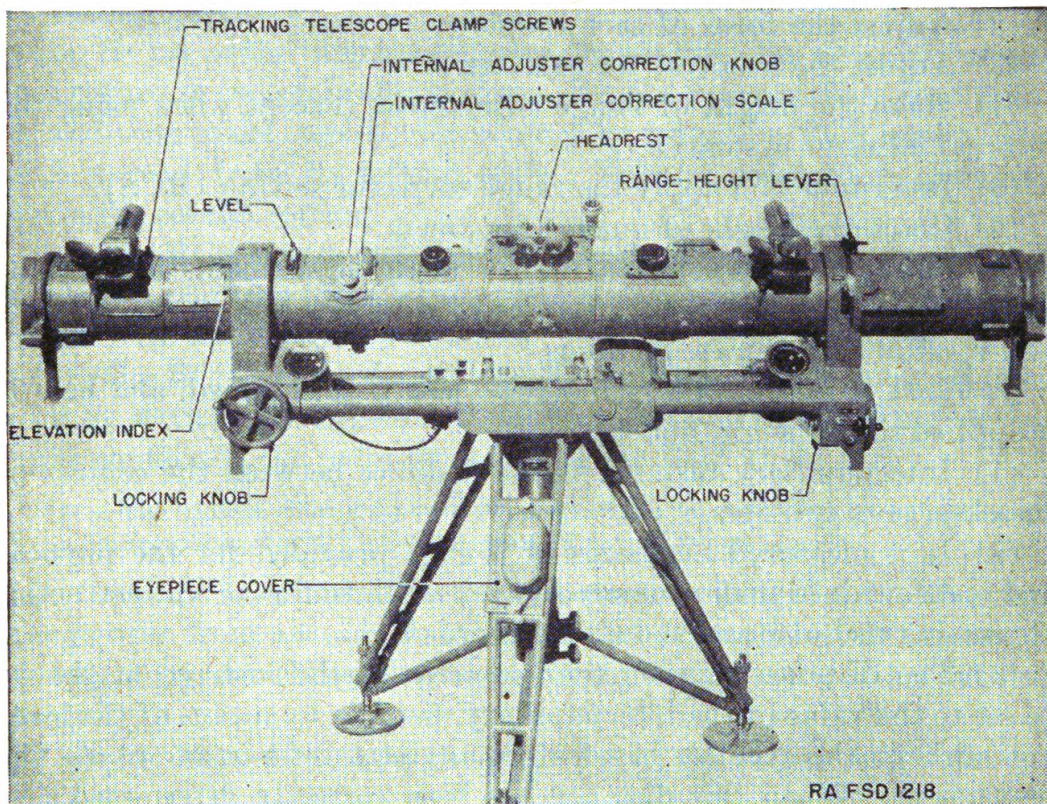


FIGURE 34.—Height finder M1, rear center view.

off the point and then move it back for a check. Readjust the orienting clutch, if necessary. Replace the dust cap.

(2) *Elevation*.—(a) Depress the tube of the instrument, using the elevation drive, until the level of the tube is centered.

(b) The mechanical (outer) dial of the elevation indicator should read zero. If it does not read zero, the instrument has either been assembled improperly or the level on the tube is out of adjustment. If improper assembling is the cause, the elevation index will not match the zero line of the height finder tube. To correct, reassemble. If the index and the zero line check, then the level vial on the tube must be adjusted by experienced personnel.

*Q.* Is this instrument provided with a means of making spot corrections in altitude?—*A.* Yes. The altitude or range transmitter is provided with a spot correction knob and dial. This mechanism permits a  $\pm 500$ -yard correction to allow for difference of altitude between the height finder and the director. The correction is + if the director is at a lower level than the height finder.

*Q.* Give the adjustments necessary to be made before employing the height finder and the sequence thereof. *A.*—

(1) Set the interpupillary distance for the person using the instrument. This setting is made on the eyepiece unit.

(2) Adjust the focus of each eyepiece.

(3) Adjust the headrest for comfort.

(4) Make the height of image adjustment (except when using the internal adjuster system).

(5) Determine and apply the range corrector setting (RCS).

(6) Check the height of image adjustment.

*Q.* Why is it necessary that the foregoing adjustments be made as accurately as possible?—*A.* In order to eliminate eye strain, fatigue, and resultant inaccurate readings.

*Q.* What is interpupillary distance, how is it obtained, and how is it applied to the height finder? *A.*—

(1) Interpupillary distance is the distance between the centers of the observer's two eyes.

(2) It is measured by means of a gage provided for the purpose and is determined under the supervision of an oculist or an instructor. It remains the same and should be recorded.

(3) The distance between the eyepieces of the instrument should be set to the value of the interpupillary distance by means of the lever and scale on the eyepiece base before any attempt is made to use the instrument. When this distance has been correctly determined and applied, the eyepieces should be in the most comfortable position for the observer, and the two circular fields (one for each eye) should blend into one.

*Q.* How is proper focus of the eyepieces obtained?—*A.* Each eyepiece should be focused separately. The eyepiece should be screwed all the way out to the largest possible diopter setting, and then gradually screwed in until the image is clear and distinct. Both eyes should be kept open while focusing and the end window of the eyepiece not being focused should be kept covered.

*Q.* How is the height of image adjustment made?—*A.* If the right and left images of the target do not appear at the same distance above the main symbol on both the right and left reticles, it will be difficult

to fuse the target image and those of the reticle symbols at the same time. The right-hand target image should be brought very close, vertically, to the main symbol, using the azimuth and elevation drives. The left-hand image is brought to the same height as the right-hand image by means of the height adjusting knob. This adjustment should always be made on a fixed target before and after an internal adjustment is made, except when using the internal adjuster system. In this case it is only necessary to make the height adjustment after the RCS has been determined.

**Q.** What three methods may be used to determine the range corrector setting (RCS)? **A.**—

(1) By use of the internal adjuster system after the proper lever has been turned to switch in this system. Set the range scale to read infinity and then make stereoscopic contact by using the RCS knob. The RCS is read from its setting scale. Take at least 10 readings to obtain the correct setting.

(2) The RCS may be determined at night by setting the range scale at infinity, pointing the instrument at a star, and making stereoscopic contact with the RCS knob as above.

(3) The RCS may be determined by adjustment on a known datum point by setting the range to the known point and then making stereoscopic contact on the point by means of the RCS knob.

**NOTE.**—The values obtained above should always be corrected by values based on the observer's curve "B" when internal adjuster system is used.

**Q.** Can this instrument be used to measure range?—**A.** Yes. The change over from altitude to range can be accomplished at any angular height by switching the range-height lever to the index labeled "range."

**Q.** Name some of the points of general care of the height finder. **A.**—

(1) When the instrument is not in use, the units should be packed in their respective carrying cases.

(2) Never allow the rays of the sun to fall directly on any exposed optical surface. Keep these surfaces covered when the instrument is not in use.

(3) Protect the instrument from sudden temperature changes. Do not allow one end of the tube to remain in the sun while the other is in the shade. Do not allow a cool wind to blow on one end of the tube while the other is protected.

(4) If the instrument is not in regular use, turn all handwheels and knobs throughout their limits of motion at least once a month. Do not force any of them. If they will not move or stop moving,

it is an indication that either a stop has been reached or the mechanism is jammed. Check the cause of stoppage.

(5) Remove dust from exposed optical surfaces by means of the soft camel's-hair brush provided. Remove moisture from these surfaces with the "selvyt" cloths that are supplied. Keep these cloths clean and in dustproof can.

**62. Stereoscopic height finder M2.**—In general, the questions applying to stereoscopic height finder M1 apply to the M2 instrument. The following questions pertain to the major differences between the two instruments.

**Q.** What is the weight of the component parts and of the entire unit when packed? **A.**—

|                             |               |
|-----------------------------|---------------|
| Tube.....                   | 670 pounds.   |
| Cradle.....                 | 255 pounds.   |
| Tripod.....                 | 115 pounds.   |
| Weight of unit, packed..... | 2,600 pounds. |

**Q.** How is the cradle set up on the tripod?—**A.** It should be so placed that the three index marks on the tripod match the similar marks on the cradle. The cradle is secured to the tripod by means of the six tripod clamp screws. Although two men may be used for this operation, it is preferable that four men, one for each transportation handle, be utilized.

**Q.** How is the tube set on the cradle?—**A.** The tube should first be set on the cradle so that the mounting blocks on the tube rest partially on the left half of the corresponding blocks on the cradle. Then, while the cradle and tripod are being held steady so as not to upset the instrument, the tube should be slid forward (away from the observer's side of the instrument) so that the machined shoulders of the corresponding mounting blocks are together. Keeping these surfaces together, the tube is then slid to the right until the rear mounting block on the tube comes firmly against the locating pin on the corresponding cradle mounting block.

**Q.** How is the range corrector setting (RCS) determined, using the internal adjuster system?—**A.** Illuminate the adjuster target by turning the lower power switch to "trans" if the source of power is 110 volts alternating current, or to "bat" if 6 volts direct current; turn the upper power switch to position "2" and rotate the adjuster knob clockwise to the end of its rotation. The RCS scale runs from 0 to 120 instead of from 0 to 100 as on the M1 instrument. After the range scale has been set to infinity, and stereoscopic contact is made approximately by use of the range corrector knob, the central measuring mark of the height finder reticle is centered between the

double lines of the adjuster target by means of the collimator adjusting knob before readings are taken to determine the correct RCS. The RCS correction determined from analysis is set in with opposite sign on the M2 instrument, while it is set in the M1 instrument with the same sign as developed on analysis.

*Q.* What additional feature is available when collimating the tracking telescopes for elevation on the M2 height finder?—*A.* The fine elevation adjustment knob can be locked in its central position by means of the lock provided, whereas on the M1 height finder this central position must be determined by eye.

*Q.* What additional adjustment is possible on the tracking telescopes?—*A.* Means are provided for setting the interpupillary distance of the tracker on each tracking telescope.

*Q.* How is azimuth collimation handled on the azimuth tracking telescope?—*A.* There is a screw for moving the cross hair laterally within the telescope, for small corrections in azimuth, as compared with the need to loosen and reset the entire telescope on the M1 instrument.

*Q.* What are some of the precautions to be observed concerning the electrical system of the M2 height finder?—*A.* When the lower power switch is turned to the proper position for the source of power (either "trans" or "bat"), position "1" on the upper switch is used when illumination is desired for the height finder reticles, and tracking telescope reticles, the range or altitude scale, and the range or altitude transmitter. This is the normal position of the power switches for night operation of the instrument. Position "2" of the upper power switch is used only when making an internal adjustment by means of the internal adjuster system. Position "1" should be used only during night operation. Position "2" should be used only when making the internal adjustment. At all other times, all switches should be turned off.

**63. Check of height finder.**—*Q.* After the height finder has been properly set up, how may it be checked for adjustment for reading correct ranges and altitudes?—*A.* After the temperature within the instrument has been allowed to stabilize, take 3 series of internal adjuster readings of 10 readings each; the first with the range-height lever in the range position and with the range scale set at infinity, the second with the range-height lever in the height position and with the altitude scale set at infinity, and the third with the range-height lever in the height position and the altitude scale set at 550. All RCS readings should be recorded to the nearest one-tenth of a unit. If the averages of the 2 series of readings taken with the range (altitude) scale set to indicate infinity differ by more than 2 divisions

of the RCS scale, the wedges are out of adjustment for reading ranges. If the averages of the 2 series taken with the range-height lever in the height position differ by more than 2 divisions of the RCS scale, the wedges are out of adjustment for reading altitudes. If the spread of the averages of the 3 series of readings is 2 units or greater, the wedges are out of adjustment for proper readings. In either of the above cases the height finder should be adjusted by experienced optical repairmen.

Q. When making this wedge check, what precautions should be taken? A.—

(1) The instrument should be in a stable condition of temperature.

(2) The instrument should be properly assembled and oriented in elevation.

(3) The RCS readings should be taken by a trained and qualified observer.

(4) The difference between the greatest and smallest reading in any series of RCS readings used for this check should not exceed two divisions of the RCS scale. A difference greater than this indicates that the observer is not sufficiently qualified to make this check.

Q. What is meant by a stable condition of temperature?—A. When the instrument has been exposed to an outside air temperature having no variation greater than  $3^{\circ}$  an hour, or  $12^{\circ}$  in 4 hours.

Q. How often should this wedge check be made?—A. Under peace-time conditions, this check should be made at least every 3 months and more frequently when the height finder is going to be used to furnish data for firing. Under service conditions, the check should be made at least once a week and at all other times when it may be suspected that the instrument has been subjected to rough handling.

**64. Altimeter M1920.**—Q. When should the short base be used?—A. When the base line length is less than the expected altitude of the targets.

Q. What should be done when the instrument cannot be leveled?—A. It indicates that the bubbles are out of adjustment and the instrument should be adjusted by ordnance personnel.

Q. What is the general cause of unusual and impossible altitude readings?—A. The B<sup>2</sup> altimeter is probably on the wrong target.

Q. How often should readings be taken?—A. The B<sup>2</sup> reader should take a reading every time a new value appears under the pointer.

Q. What is the best method of orientation?—A. The best and easiest method of orientation is with stations intervisible.

Q. What care should be given the telescope and lenses?—A. The telescope should be handled carefully and not subjected to any undue

shocks. The lenses should be dusted off and cleaned with soft cleaning paper furnished for that purpose.

**65. Director M4.—Q.** Describe the steps in setting up the director for use. **A.—**

(1) Set the pedestal in place on a firm surface and level it approximately by eye, using the three leveling screws in the feet of the pedestal.

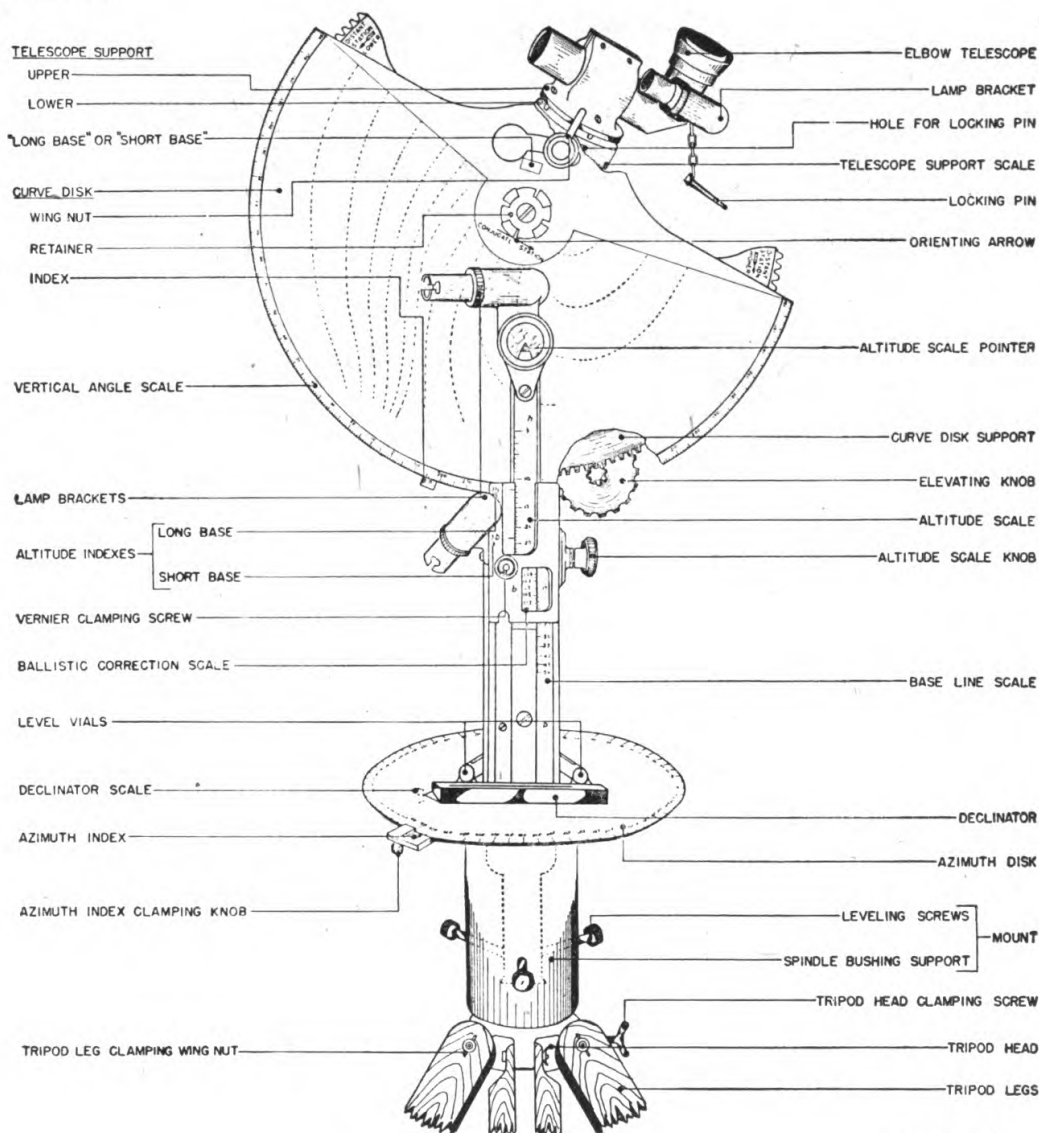
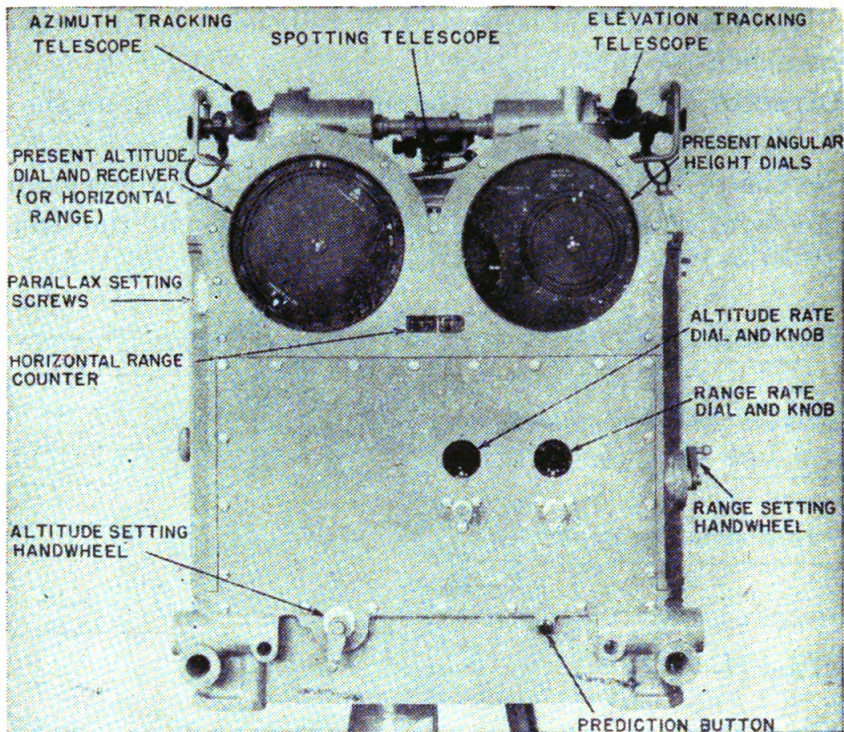


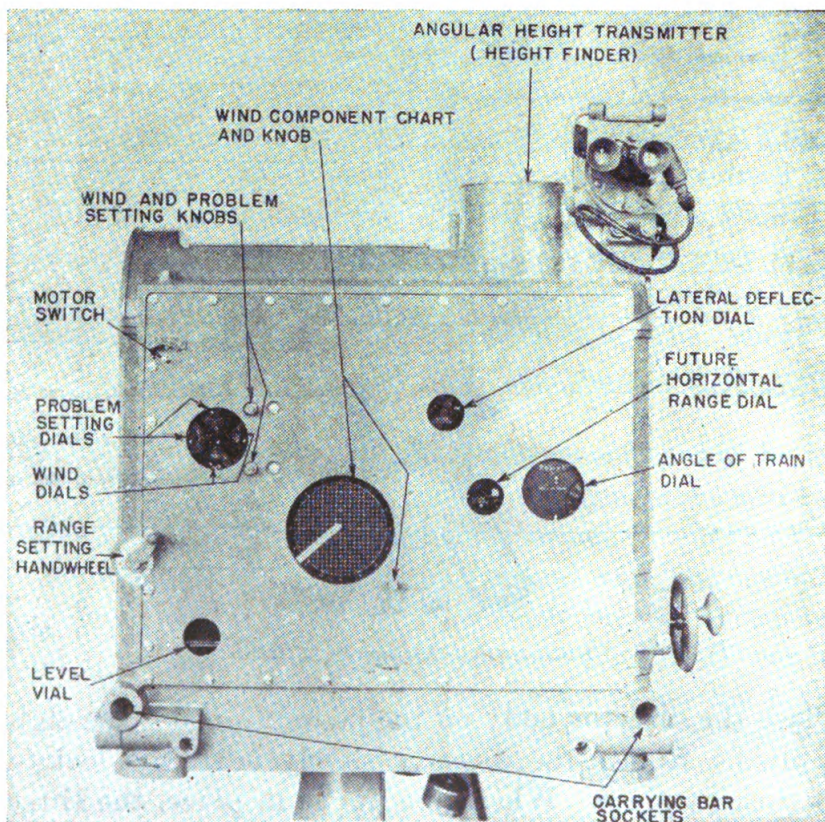
FIGURE 35.—Altimeter M1920.

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(2) Place the director body on the pedestal, using the eight porter bars supplied. Rotate the director slowly until the locking pin is heard to click in place. When this pin is in place, the three clamping screws in the upper part of the pedestal are lined up with the three clamping holes in the base of the director.

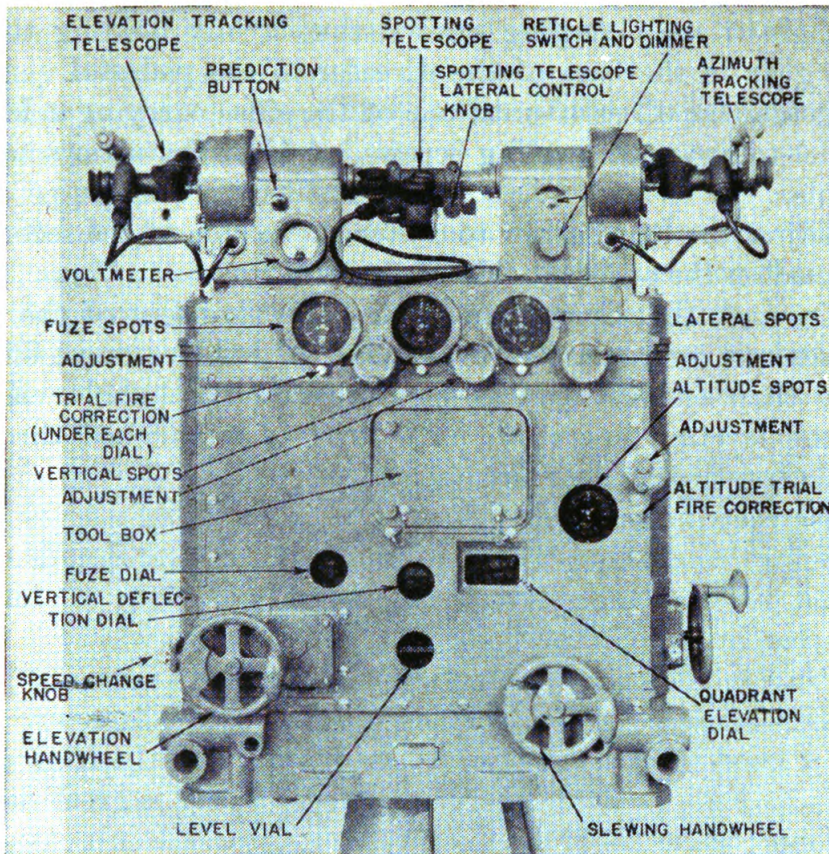


① Front.

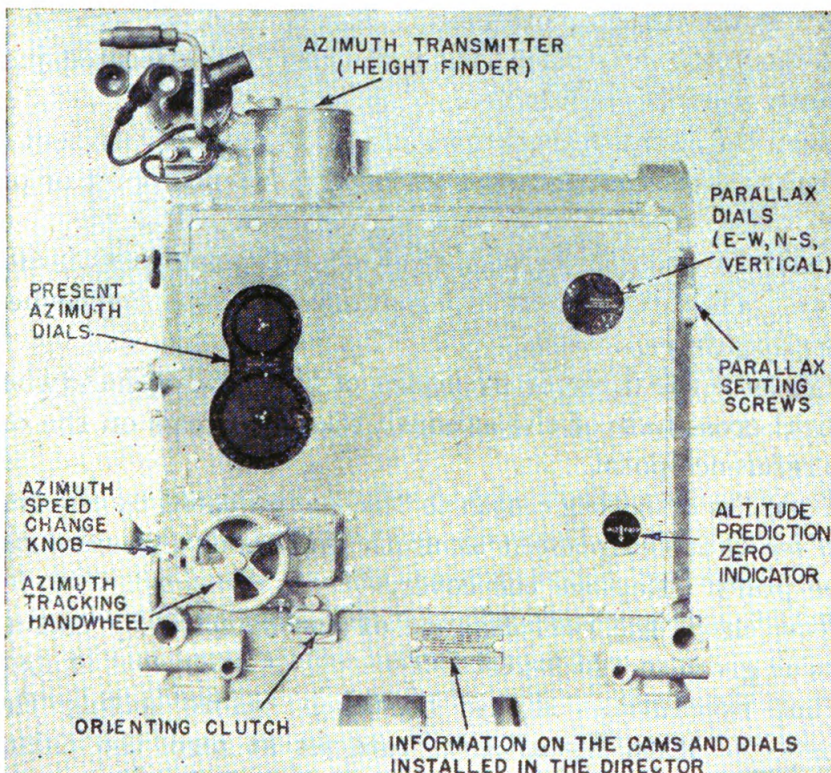


② Left.

FIGURE 36.—Director M4.



① Rear.



② Right.

FIGURE 37.—Director M4.

(3) Tighten the clamping screws, thus firmly holding the large azimuth gear in the base of the director to the pedestal.

(4) Rotate the director until one of the sides carrying a level vial is parallel to any two leveling screws. Adjust the screws to center the bubble.

(5) Adjust the third screw to center the bubble of the second level vial carried on the adjacent side of the director.

(6) Traverse the director and note any movement of the bubbles from center at each quarter revolution. If bubbles move off center by more than one division as measured on the bubble vial scale, repeat the leveling operation until level is established throughout the whole traverse of the instrument.

(7) See that the power is off.

(8) Before connecting the cable plugs, place several coils of cable inside the pedestal hollow to permit several complete revolutions of the director in azimuth without twisting the cable.

(9) Plug in the cables from the height finder and main junction box in their respective receptacles in the base of the director.

Q. Is it good practice to power the director directly from a power source?—A. No. It should never be done. There is great danger of burning out the electrical circuits in the director. In all cases, power the director through the main junction box.

Q. How is the director oriented? A.—

(1) Remove the cover from the orienting clutch located just below the azimuth tracking handwheel.

(2) Turn the azimuth tracking handwheel until the present azimuth dial indicates the azimuth of the assigned reference point or orienting mark.

(3) Turn the orienting clutch to the "out" position as indicated by the arrow. This disconnects the azimuth tracking handwheel from the traversing drive.

(4) Traverse the director by means of the slewing handwheel until the vertical cross hair of the azimuth telescope rests on the orienting mark or reference point.

(5) Turn the orienting clutch to "in" as indicated by the arrow and check to see that the present azimuth dial reads the azimuth of the reference point. Replace the cover.

(6) Now check the performance of the director by setting check problems as given in TM 9-2655.

Q. What precautions should be taken before setting the check problems?—A. With the altitude rate set at zero, the altitude prediction motor switch should be turned to "on" for about 10 seconds

and then turned off. This action will remove any altitude prediction that may have been left in the director.

*Q.* How is electrical synchronization of the director, height finder, and guns accomplished? *A.*—

(1) Apply power to the system.

(2) Read and record the values of present azimuth, angular height, angle of train (firing azimuth), quadrant elevation, and fuze as indicated on the proper dials of the director.

(3) Without moving any element of the director mechanism, compare the values of the present and angular height with those indicated

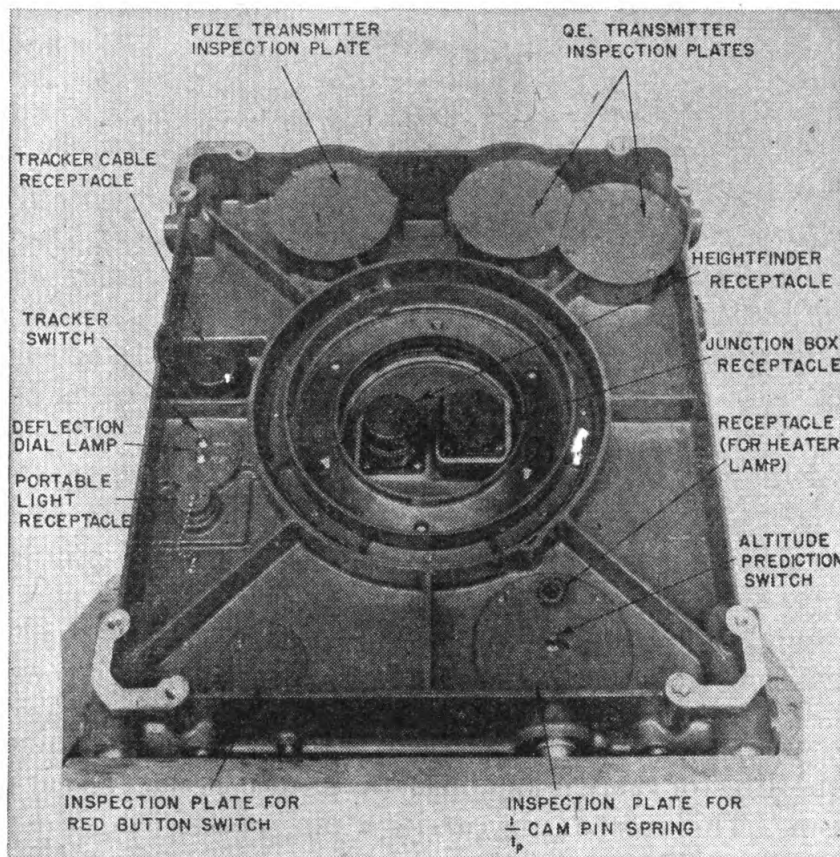


FIGURE 38.—Director M4, under side, off pedestal.

by the electrical pointers on the height finder receivers. Also check the altitude as received by the electrical pointer at the director against that indicated at the height finder transmitter. If these values do not agree, make the necessary adjustments by rotating the housings of the units at the height finder.

(4) Still without moving any element of the director mechanism, compare the values of angle of train (firing azimuth), quadrant elevation, and fuze with those indicated by the electrical pointers on the receivers at each gun. If the gun values do not agree with

the director values, make the necessary adjustments by using the synchronizing screws on the gun receivers.

*Q.* What method of prediction is used in this director?—*A.* The linear speed method.

*Q.* How is the linear speed of the target determined?—*A.* The speed of the target is not computed directly. The rate of change of target position is measured in a north-south and east-west direction by mechanical means within the director. These values are so handled mechanically as to produce prediction along the path of the target.

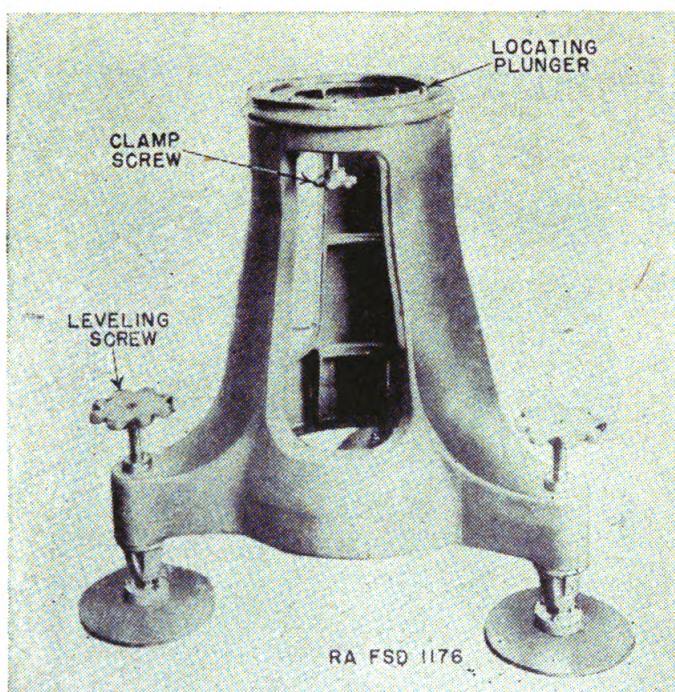


FIGURE 39.—Pedestal, director M4.

*Q.* How is the north-south and east-west rate determined?—*A.* Within the director there is an apparatus known as the present position mechanism. This mechanism carries a pin representing the position of the target projected on the ground surface. The operation of tracking the target in azimuth and elevation combined with the set-in value of altitude causes this pin to move along the path of the target. The movement of the pin causes each of two gear racks to drive a gear, one in a north or south direction and the other in an east or west direction. The rate of rotation of these gears is measured mechanically and automatically.

Q. What are the limits of operation of the director? A.—

|                               |                            |
|-------------------------------|----------------------------|
| Present azimuth.....          | No limit.                  |
| Present altitude.....         | — 320 to + 8,350 yards.    |
| Present angular height.....   | — 175 to + 1,600 mils.     |
| Present horizontal range..... | 250 to 15,750 yards.       |
| Target speed.....             | 0 to 200 yards per second. |
| Wind correction.....          | 0 to 50 miles per hour.    |
| Time of flight.....           | 4 to 33 seconds.           |
| Battery parallax.....         | 0 to 450 yards.            |
| Future horizontal range.....  | 250 to 15,750 yards.       |
| Future azimuth.....           | No limit.                  |
| Present altitude spot.....    | ± 450 yards.               |
| Vertical parallax.....        | ± 450 yards.               |
| Lateral spot.....             | ± 140 mils.                |
| Vertical spot.....            | ± 50 mils.                 |
| Fuze spot.....                | ± 2.5 fuze numbers.        |
| Quadrant elevation.....       | — 135 to + 1,600 mils.     |

Q. Is this director capable of computing data for diving or climbing targets?—A. Yes. The director is provided with a means of measuring the rate of change of altitude and predicting in altitude.

Q. Is this director capable of being used for horizontal fire?—A. Yes. The change from AA fire to horizontal fire is simply and easily accomplished as follows: Upon command "Horizontal fire," the altitude setter transfers his attention to the angular height dials and matches the pointer thereon by means of his altitude handwheel; the range setter transfers his attention from the angular height dials to the altitude receiver dials and matches the pointer marked "Hor" with his range handwheel, and maintains match with his range rate knob. The altitude receiver is now being positioned in range by the height finder. This operation takes no longer than the time necessary to move the eyes from one point to another.

Q. Can the director take care of more than one combination of fuze and projectile?—A. Yes. By changing the cams in the director and certain dials on the back of the director.

Q. Is this operation of changing cams one to be performed indiscriminately by the battery?—A. No. It is only done when conditions demand it and by qualified personnel in a room free from floating dust and dirt.

Q. What is usually the cause of a sudden break in the functioning of the director (stoppage of motors) when tracking a target and the voltmeter indicates power is still applied to the director?—A. An unreasonable condition has probably been set up in the director, either causing a stop switch to open or the director to go into one of its two interlock positions.

Q. How is this condition cleared?—A. By following in exact sequence the steps indicated in the director handbook.

Q. Is it permissible to slew the director around with slewing handwheel with power on the prediction motors?—A. No. This will set up impossible conditions within the director. Power should be turned off the prediction motors or the red button should be pushed in to freeze prediction while slewing rapidly to a new target.

Q. Can this director compute data for guns using sights instead of data receivers?—A. Yes. Lateral deflection, vertical deflection, and fuze range can be read from the proper dials.

Q. How should large altitude spots or large errors in matching of the angular height pointers be handled?—A. Large and sudden

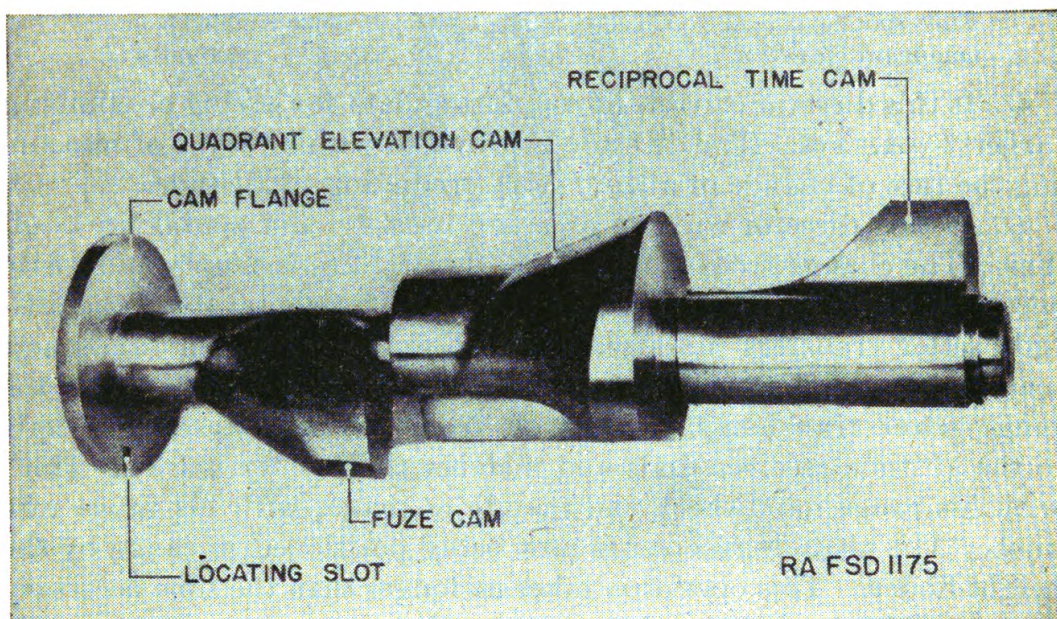


FIGURE 40.—Three-dimensional ballistic cam.

changes in these elements will cause large variations in firing data sent to the guns and consequently large errors. When large altitude spots are put in or in correcting large errors in matching angular height pointers, the red button should be pushed in and held in for 5 seconds. This action turns off the prediction motors while the director is settling down to a new prediction. In other words prediction is frozen at its present value. When the red button is released, the director moves to the new prediction smoothly and easily.

Q. How is the trial shot problem set into the director? A.—

(1) Select a trial shot point depending upon the conditions of weather or cloud altitude and upon the combination of gun and ammunition. The altitude and angular height combined with azimuth from the director fixes the point in space.

(2) Traverse the director until the present azimuth dial indicates the value of the selected azimuth of the trial shot point.

(3) Elevate the tracking telescopes until the angular height of the selected point is indicated on the outer ring of the angular height dial.

(4) Set on the altitude dial the correct value of the altitude of the trial shot point.

(5) Select the proper zone of the meteorological message and extract from it the values of wind speed and direction. By means of the wind revolving mechanism on the side of the director, measure the east-west and the north-south components of the wind. Set these values in the director on the wind and problem setting dials.

(6) Set in on the parallax dials the value of any parallax that may exist. This includes both vertical and horizontal parallax of the director with respect to the guns. The values should always be set in the direction, director from guns. If the director is 205 yards west, 79 yards north, and 50 yards above the guns, the following values should be set: 205 yards west, 79 yards north, and 50 yards above on the proper parallax dials.

(7) Set in the values of lateral, vertical, fuze, and altitude corrections as determined by the range officer on the lateral, vertical, fuze, and altitude spot dials.

(8) Match the pointer on the outer ring of the angular height dial with the pointer on the inner ring of the angular height dial by use of the range setting handwheel.

(9) Turn on the prediction motor switches and let the motors run for a few seconds. This will set in the values of wind and parallax. Check the match of all pointers and turn motors off.

(10) The director has now computed the necessary firing data and has transmitted it to the guns.

*Q.* Should aimless turning of handwheels and knobs be allowed?—

*A.* No. Such practice may do extensive damage to the director mechanism.

*Q.* When the director is to be placed in storage, what precautions should be taken? *A.*—

(1) The director should be covered with its canvas cover and placed in a dry room. If dampness makes its appearance or the using station is in the Tropics, plug in the heater lamp cord to its receptacle on the base of the director and connect to a 110-volt a-c source of power. This lamp should be left on to suit storage conditions.

(2) All moving parts, including handwheels, spot knobs, range and altitude rate knobs, prediction and constant speed motors, should be exercised once every 2 weeks. The moving parts should travel from

stop to stop or through a complete revolution if operation is not limited by a stop.

*Q.* What should be done if handwheels or knobs meet resistance while being turned?—*A.* *Stop turning. Do not force. Report the trouble immediately.*

**66. Directors M3 and M3A1.**—*a. Director M3.*—*Q.* What method of prediction is used in this director?—*A.* The linear speed method.

*Q.* How is the ground speed determined?—*A.* By measuring the rates in a north-south and east-west direction.

*Q.* What device is used to measure the rates?—*A.* A tachometer, a rate-measuring instrument which is driven whenever the director is traversed. Two of these instruments are located on the right-hand side of the director.

*Q.* What causes the tachometer to measure the rate in a north-south or east-west direction when the director is traversed?—*A.* In the director there are two slides which intersect at the horizontal projection of the target. One slide is free to move in a north-south direction only. The other slide is free to move in an east-west direction only. A pin representing the horizontal projection of the target holds the slides together at their intersection. As the target is tracked the target position pin moves the slides in a north-south and east-west direction. This motion is transmitted to the tachometers by gears.

*Q.* What does the operator do to measure and set the rate into the director?—*A.* He starts the tachometer by pressing and releasing the tachometer operating lever. The tachometer pointer will move around to the measured rate and stop. The operator then sets this rate into the director by matching the tachometer pointer by turning the rate handwheel which drives an outer pointer. When this is done, the operating lever is pressed again and the operation repeated.

*Q.* What is the maximum north-south or east-west rate for which this instrument is designed?—*A.* One hundred and twenty-five yards per second or about 250 miles per hour.

*Q.* Explain how to make wind corrections.—*A.* In setting in wind corrections, the ballistic wind must be resolved into north-south and east-west components. A wind component indicator is provided on the front of the director for this purpose. The wind components are then set on the wind scale above the wind pointer (rate matching pointer).

*Q.* Explain how to orient the director.—*A.* The director is traversed until the present azimuth dial reads the azimuth of the

datum point. The orienting clutch is then disengaged and the director traversed until the vertical wire of the azimuth tracking telescope is on the datum point. The orienting clutch is engaged. Orientation should be checked by sighting again on the datum point after traversing off to right and left.

*Q.* Must this instrument be set up at or near the guns?—*A.* No. Parallax corrections may be applied so that it may be located anywhere within a square 2,000 yards on a side with the guns at the center.

*Q.* How are the parallax corrections set in the director?—*A.* The distance in yards that the director is offset from the guns in a north-south and east-west direction must be determined first. This is set on the parallax dials in the direction, guns-director.

*Q.* How many electric motors are there in this director?—*A.* Three. A constant speed motor for driving the range rate mechanism; an azimuth difference motor; and a range difference motor.

*Q.* How many data transmitters and receivers are there in the director exclusive of the target-designating system?—*A.* Three transmitters and one receiver. The transmitters are for firing azimuth, quadrant elevation, and fuze, which are transmitted to the guns. The receiver is for altitude received from the height finder.

*Q.* Can this director be used for horizontal fire?—*A.* Yes.

*Q.* How is the system changed over for horizontal fire?—*A.* In order to change over for horizontal fire it is necessary to shift the clutch on the left side from "AA fire" to "hor. fire." This shift can be made only when range and altitude are equal. This is accomplished by following the instructions on the cover plate.

*Q.* What should be done when a handwheel turns hard or a friction device sticks?—*A.* Report the trouble; under no circumstances attempt to force the handwheel past the obstruction.

*Q.* Is it permissible to remove the cover plates to look at a mechanism?—*A.* No. Covers may be removed only under the supervision of an officer, and then only in a dry place protected from blowing sand or dirt.

The candidate should be required to demonstrate his knowledge covering the following points:

- (1) How the spotting and tracking sights are collimated.
- (2) How to set up the instrument to compute firing data for trial shots; how to observe trial shots; and how the trial shot corrections are applied.
- (3) How synchronization of the data system with the guns and height finder is verified.

(4) How the director and guns are oriented when no datum point is available.

(5) How the electric motors are tested for operation and what is done in case of failure.

(6) How the trailer is loaded (where equipment is stored) at the command MARCH ORDER.

*b. Director M3A1.*—The same questions apply to this instrument as to director M3. It is identical with the M3, except that it conforms to the greater range of the 105-mm gun.

### SECTION III

## OBSERVATION AND ADJUSTMENT OF FIRE

|   | Paragraph |
|---|-----------|
| General.....  | 67        |
| Flank spotting instrument M1.....                     | 68        |
| Observation instrument AA, BC, M1 (BC telescope)..... | 69        |

**67. General.**—*Q.* What is adjustment of fire?—*A.* The process of determining and applying corrections to firing data to bring the center of burst to the adjusting point (short of the target) and keep it there.

*Q.* Why is adjustment necessary?—*A.* Because, even after the most careful preparations for firing, the center of burst may not be on the adjusting point. Adjustment of fire is a continuous process throughout all firing, for even though the center of burst has been placed on the target or the adjusting point, varying conditions may cause it to diverge.

*Q.* How are deviations obtained?—*A.* By observing the locations of the bursts with reference to the target. The process of determining deviations is called spotting.

*Q.* How must the center of burst be located?—*A.* The location of the center of burst of a group of shots with reference to a moving aerial target must be made in three dimensions. A particular burst may be—

- (1) Above or below the target (deviation in vertical deflection).
- (2) Right or left of the target (deviation in lateral deflection).
- (3) Over or short of the target (deviation in range).

*Q.* How are these deviations determined?—*A.* Vertical and lateral deviations can be determined from the battery position. Range deviations can be determined with an observation instrument at a flank station or by using a stereoscopic height finder at the battery position. Observation may be on single bursts or on the center of bursts.

**Q.** What is meant by unilateral spotting?—**A.** Lateral and vertical deviations are obtained with a BC telescope located near the battery position and are read in angular units (mils). Range deviations are determined by using a stereoscopic height finder at the battery position as a spotting instrument. Ordinarily only sensings are obtained, but the magnitude, where possible, is given in such general terms as "way over," "over," "hit," "doubtful," "short," and "way short."

**Q.** How does bilateral spotting differ from unilateral spotting?—**A.** With bilateral spotting, range deviations are obtained with a telescope located at a distant station and are read in angular units (mils), over or short of the target or TSP.

**Q.** Using the unilateral method of spotting, what conversion is necessary to the deviations as observed?—**A.** It is sufficiently accurate to accept the full value of the lateral deviation as read by the lateral deviation observer for angular heights from zero to 600 mils. For other angular heights the deviation as read should be multiplied by factors as indicated below:

|                          |     |
|--------------------------|-----|
| 600 to 1,000 mils.....   | 1.5 |
| 1,000 to 1,200 mils..... | 2.0 |
| 1,200 to 1,400 mils..... | 4.0 |

The vertical deviation as actually read in the observation instrument may be accepted without change for use in adjustment of fire, as being sufficiently accurate. No conversion for range is necessary, as only sensings are given.

**Q.** Why is lateral conversion necessary?—**A.** Since the lateral deviation is measured in an inclined plane, it must be reduced to a corresponding value in the horizontal plane in order that it may be applied correctly as an adjustment correction on the director.

**Q.** Using the bilateral method, what conversion is necessary for range deviations?—**A.** They must be converted into deviations in altitude.

**Q.** Why should vertical and lateral corrections be prompt and continuous?—**A.** Because, until the center of burst is on the line of position, telescopic observation of fire from the distant station will be unreliable and stereoscopic observation from the battery position will be impossible.

**Q.** Where are vertical and lateral corrections made?—**A.** On the director.

**Q.** In what terms are range corrections made?—**A.** In terms of altitude. These corrections have the effect of moving the burst in or out along the line of position, thereby changing the slant range.

*Q.* Where is the range (altitude) correction made?—*A.* On the director.

*Q.* When is the battery adjusted?—*A.* A battery is adjusted when mixed overs and shorts, with a preponderance of shorts, are obtained on the line of position.

*Q.* What are the three methods of range adjustments?—*A.* Modified bracketing; angular unit; fuze range pattern.

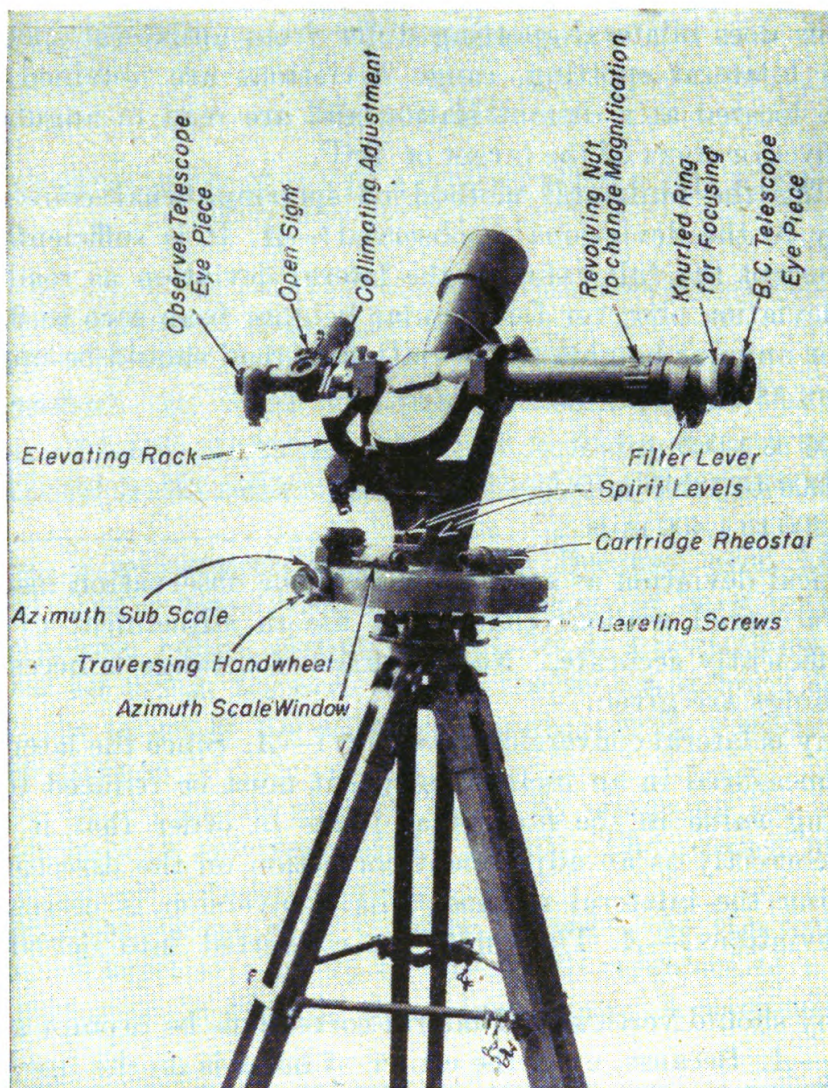


FIGURE 41.—Observation instrument, AA, BC, M1 (BC telescope).

*Q.* What is the unit of adjustment in the modified bracketing method?—*A.* The fork or 4 percent of the altitude.

*Q.* What is the size of the correction?—*A.* Corrections should be made according to the following table:

|           |                    |            |             |
|-----------|--------------------|------------|-------------|
| Way over: | Down 2 or 3 forks. | Doubtful:  | No change.  |
| Over:     | Down 1 or 2 forks. | Short:     | Up 1 fork.  |
| Hit:      | No change.         | Way short: | Up 2 forks. |

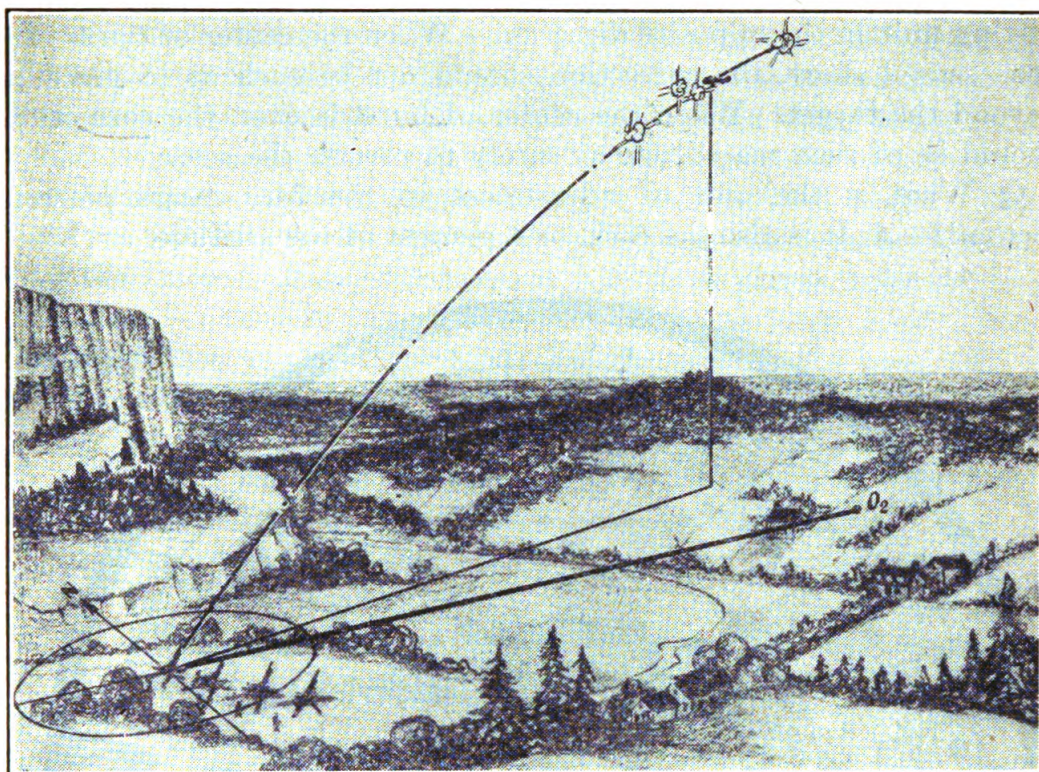


FIGURE 42.—Fuze range pattern.

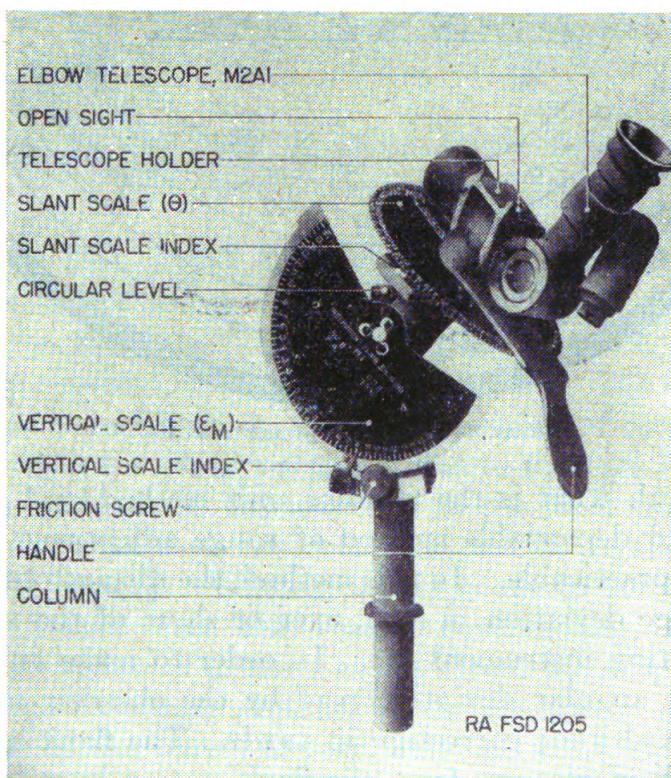


FIGURE 43.—Flank spotting instrument M1.

When the sense is reversed, apply a correction of one-half of the adjusting unit in the opposite direction. When the center of burst has been sensed short, the correction should not be such as to place it beyond the target. When the center of burst is over, the correction should be of such magnitude as surely to reverse the sense.

Q. What is the unit of adjustment in the fuze range pattern method?—A. It is also the fork, or 4 percent of the altitude.

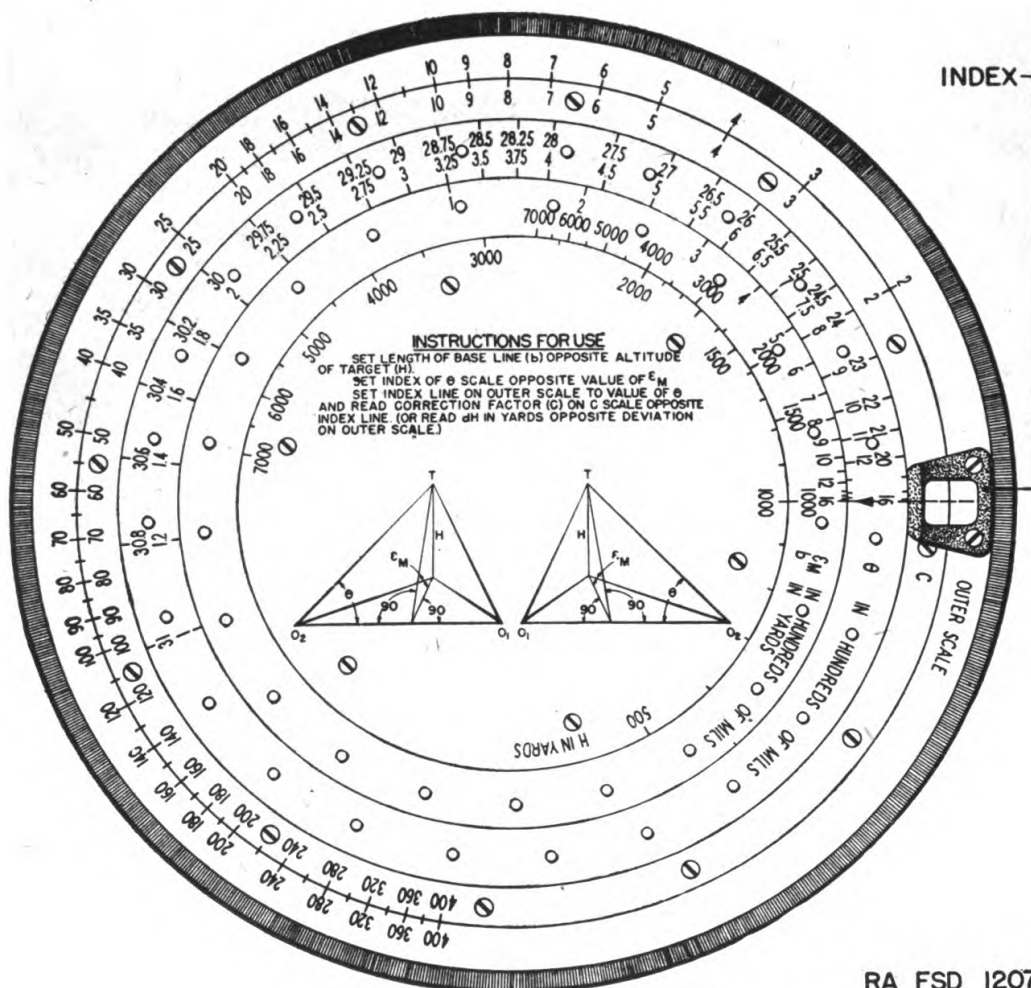


FIGURE 44.—Flank spotting rule M1.

Q. In general, what is the angular unit method?—A. This is the most rapid and dependable method of range adjustment and should be used when practicable. In this method, the distant observer determines the range deviation in mils, over or short of the target, using the flank spotting instrument M1. In order to make an adjustment correction, the angular deviation read by the observer must be converted into an altitude correction in yards. The flank spotting rule M1 converts the deviations from the flank station in mils to altitude correction in yards.

**68. Flank spotting instrument M1.—Q.** Describe briefly the flank spotting instrument M1.—**A.** The instrument consists of a tripod, base, instrument proper, and telescope. The telescope rotates around two axes perpendicular to each other, one motion being in the vertical plane of the  $\epsilon_m$  (epsilon sub m) scale (perpendicular to the spotting base line), the second motion being in the inclined plane. The  $\epsilon_m$  and the  $\theta$  (theta) scales with their pointers provide means for measuring the amount of angular movement in these planes imparted to the telescope. For orienting purposes, a clamping knob is provided so that the instrument proper may be clamped to the base with the index of the vertical plane  $\epsilon_m$  scale at the zero setting. The telescope is of the elbow type. The reticle is equipped with a mil scale.

**Q.** How is the flank spotting instrument set up and oriented?—

**A.** The instrument is set up and oriented as follows:

- (1) Set up and level the tripod.
- (2) Screw the base firmly in position.
- (3) Place the instrument proper on the vertical shaft of the base.
- (4) Insert the elbow telescope in the bracket and tighten the clamp screws.
- (5) Set the  $\epsilon_m$  mil scale so that the zero mil graduation is opposite the pointer and clamp in position. This places the  $\theta$  scale in a horizontal position so that it can be used to set off azimuths.
- (6) Rotate the instrument proper on its vertical shaft until the pointer "to battery" on the  $\theta$  scale is pointing in the direction of the battery station.
- (7) Clamp the instrument proper to its base by means of the clamping knob. This clamps the  $\epsilon_m$  scale in a plane perpendicular to the base line.
- (8) Loosen the  $\epsilon_m$  scale clamping screw. The instrument is now oriented and ready for operation.

**Q.** Describe the operation of the instrument.—**A.** For operation two men are required, an observer and a reader. The observer tracks the target by a combination of the two motions of rotating the main telescope axis in the plane perpendicular to the base line and sweeping the line of sight of the telescope in the slant plane. Both the observer and reader wear headsets connected in parallel to the range officer at the battery. When firing is about to start, the observer tracks the target and the reader continuously announces the instantaneous values of  $\epsilon_m$  and  $\theta$  as read from the proper scales. The observer keeps the target centered on the cross hairs of the telescope and, as soon as the bursts appear, announces the deviations of the bursts indicated by the mil values on the horizontal cross hair scale.

From time to time, the reader may announce new values of  $\epsilon_m$  and  $\theta$ , choosing his times so as not to interfere with the calling of the deviations.

**69. Observation instrument AA, BC, M1 (BC telescope).—**

*Q.* Describe briefly the BC telescope M1.—*A.* The BC telescope M1 is the base of an azimuth instrument M1918, equipped with a special trunnion support and carrying two right-angle telescopes, one for tracking and one for spotting.

*Q.* In what units is the instrument graduated?—*A.* The azimuth and angular height scales are graduated in mils.

*Q.* What are the three parts of the instrument?—*A.* The tripod, mount, and telescope.

*Q.* How many optical systems are contained in this instrument?—*A.* Two.

*Q.* What are the two systems?—*A.* The tracking and spotting optical systems.

*Q.* How is the instrument traversed and elevated?—*A.* The instrument is traversed in slow motion by the traversing handwheel and in elevation by the elevating handwheel.

*Q.* How many men operate the elevating and traversing handwheels?—*A.* The tracker controls the instrument in both azimuth and elevation by means of the two handwheels.

*Q.* What is the type and power of the tracker's telescope?—*A.* The tracker's telescope is a standard M2 elbow telescope of 8 power.

*Q.* What is the purpose of the amber filter?—*A.* The amber filter is for use in brilliant light or haze.

*Q.* What means are provided for initial location of the target?—*A.* An open sight is provided.

*Q.* How is the instrument set up?—*A.* The tripod is set up over the designated point. The mount is screwed onto the tripod head and the telescope placed on the cap squares provided in the mount.

*Q.* How is the tripod set up so as to bring it directly over the designated point?—*A.* The tripod legs are spread so as to form a solid base. The plumb bob string is attached to the hook underneath the tripod head. The tripod is moved so as to place the point of the plumb bob exactly over the station marker. The head of the tripod is leveled approximately, using the bubble in the head as a guide.

*Q.* How is the mount attached to the tripod?—*A.* The mount is screwed to the tripod head so that it has a firm bearing.

*Q.* How is the telescope mounted?—*A.* The screws on the trunnion cap squares are unscrewed and the cap squares opened. Grasping the telescope at the elbow junction of the spotting telescope, the tele-

scope is placed in the trunnion beds so that the objective end of the telescope is on the same side of the mount as the elevating handwheel. The trunnion cap squares are folded down and screws tightened so as to secure a firm bearing surface between trunnions and cap squares.

*Q.* How is the instrument leveled?—*A.* The instrument is provided with two spirit levels at right angles to each other, and four level screws. Traverse the mount so that level screws lie along the line of two opposite leveling screws. Bring bubbles to center of level tubes. Traverse through  $180^\circ$  and check level. When bubbles remain centered at all points in field of traverse, instrument is level.

*Q.* How is the BC telescope oriented?—*A.* Set the approximate azimuth to the orienting point under the azimuth indicator window. By loosening two adjacent leveling screws, rotate the head so telescope is pointed approximately at the orienting point. Level the instrument. When leveling is complete, set the exact azimuth of the orienting point on the azimuth scale and vernier. If the vertical hair is not on the orienting point, loosen the azimuth release clamp screw and bring the vertical wire to the point. Tighten the azimuth release clamp and bring the vertical hair into exact coincidence with the orienting point by means of the azimuth adjustment tangent screw.

*Q.* What checks should be made after orienting?—*A.* The instrument should be traversed away and brought back to the orienting point several times, using the azimuth traversing handwheel. If readings do not agree, further adjustment should be made with the azimuth adjustment tangent screw.

*Q.* How may large errors in orientation be detected?—*A.* Read the azimuth to several other points whose azimuth is known, and compare with the correct azimuth. If they do not agree, the instrument is not properly oriented.

*Q.* Where is the azimuth read?—*A.* The azimuth is read under the main azimuth scale window and on the periphery of the azimuth traversing handwheel.

*Q.* What is the smallest graduation on the main azimuth scale?—*A.* Ten mils.

*Q.* What is the smallest graduation on the azimuth vernier scale?—*A.* One-tenth of a mil.

*Q.* Where is the angular height read?—*A.* Angular height is read on the vertical limb angular height scale and angular height vernier.

*Q.* What are the smallest graduations on the main and vernier angular height scales?—*A.* The least reading on the main scale is 100 mils and on the vernier scale 1 mil.

Q. What happens to the cross hairs when the instrument is elevated?—A. The cross hairs are inclined as the instrument is elevated.

Q. How is the instrument used at night?—A. Illumination is provided for the azimuth and angular height scales and cross hairs of both telescopes from a 4-volt storage battery through a system of wires, sockets, and bulbs. The instrument is used the same as for day operation.

Q. How may amount of illumination be controlled?—A. Intensity of illumination is controlled by means of a cartridge rheostat.

Q. How many powers are available in the spotting telescope and how may they be changed?—A. Two powers, 10 and 20. The desired power is selected by turning the knurled collar on the telescope.

Q. How are angular deviations obtained with this instrument?—A. The spotting telescope cross hairs are graduated into 5-mil graduations. The spotter obtains deviations by reading along the horizontal and vertical scales.

Q. What precautions should be taken in handling the BC telescope?  
A.—

- (1) Lenses should never be touched with the fingers.
- (2) Clean the lens with a soft brush or optical paper.
- (3) Do not jar the instrument.
- (4) Do not set up leveling screws too tightly.
- (5) Do not make any adjustments on instruments.
- (6) Do not tamper with the optical system.

Q. What care should be taken in regards to lubrication?—A. Only neutral oil should be used. All moving parts should be lubricated with a few drops worked over the surface and excess wiped off. Telescope trunnions and cap squares must be kept clean and bright at all times. Dust and grit should be wiped off when the instrument is taken out of action.

Q. How are telescopes collimated?—A. By target or by the use of a distant object. The latter is used in the field.

Q. How is collimation accomplished in the field?—A. If during daylight, traverse the instrument to put the intersection of the spotting telescope cross hairs on an easily distinguished point of an object at least 5,000 yards away. Cross hair intersection of tracker's telescope is brought to the same point by varying the tension on the lateral and vertical collimation tension bolts. Collimation may be accomplished easily at night by using a bright star as the collimating point.

## SECTION IV

### ORIENTATION—USE OF TRANSIT

|                            | Paragraph |
|----------------------------|-----------|
| General .....              | 70        |
| Operation of transit ..... | 71        |
| Transit traverse .....     | 72        |

**70. General.**—*Q.* What is the most practical method of locating gun positions?—*A.* By means of a traverse from some point whose location is known. By traversing is meant the determination of the lengths and azimuths of a series of straight lines usually extending from a known point to the point desired.

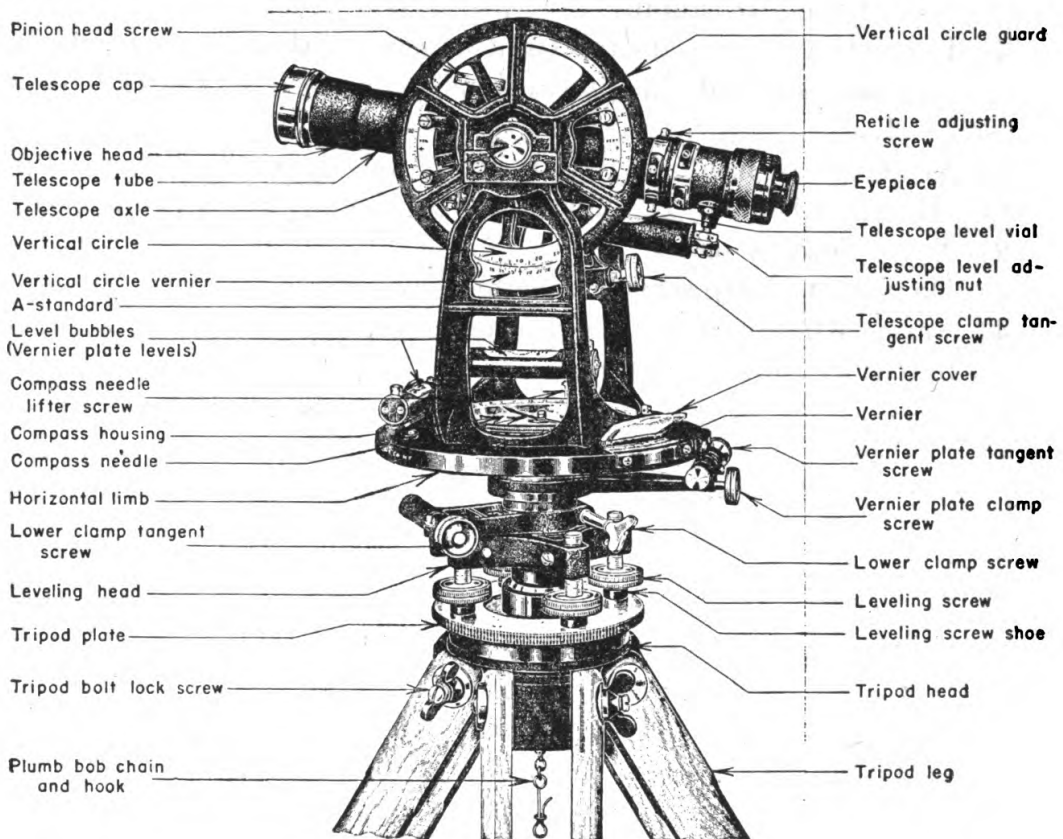


FIGURE 45.—Engineer's transit.

*Q.* What instruments are used in making a traverse?—*A.* A plane table with telescope alidade or a transit.

*Q.* What are the uses of a transit?—*A.* The transit is the most useful and universal of all surveying instruments. Besides measuring horizontal and vertical angles, it may be used to determine bearings by means of the compass and for leveling by means of the long bubble under the telescope. Distances may also be measured by means of stadia wires in the telescope.

**71. Operation of transit.**—*Q.* What are the steps in setting up a transit set? *A.*—

- (1) Adjust the plumb bob over the stake.
- (2) Level the instrument.
- (3) Focus and eliminate parallax.

*Q.* Describe in general terms the method of leveling a transit or similar instrument. *A.*—

(1) Turn the plates so that each plate level is parallel to a pair of opposite leveling screws. Each level is then controlled by the pair of leveling screws which lie parallel to it.

(2) Always move the two screws either toward each other or away from each other, not in the same direction. The bubble will follow the motion of the left thumb.

(3) If leveling screws are too tight unscrew either but not both.

*Q.* What are some of the precautions to be used in the care of a transit? *A.*—

(1) Never lift or hold the transit by the telescope or telescope supports. Grasp it beneath the horizontal limb or by the leveling head.

(2) Never force a screw.

(3) Do not set clamp screws as tight as possible.

(4) Never attempt to rotate the telescope, plate, or limb without seeing that the clamp is loosened.

(5) Do not rub off the object glass with a cloth. Blow it off or brush it off gently.

*Q.* What should be done before moving a transit from one position to another. *A.*—

(1) Loosen the lower motion clamp.

(2) Point the telescope straight up and clamp very lightly.

(3) Lift the needle from the pivot if it has been used.

*Q.* How is a deflection angle measured? *A.*—

(1) With the transit pointing at the station in rear (back sight), read and record the readings of both the *A* and *B* verniers.

(2) Reverse the telescope by turning it 180° on its horizontal axis or trunnions, and note whether the forward station is to the right or left of the line of sighting. If the forward station appears on the right of the line of sighting with the telescope reversed, the deflection angle will be plus; and if on the left, minus.

(3) With the telescope still reversed, unclamp the upper motion, direct the line of sighting upon the next station, clamp the upper motion, and record the readings of verniers *A* and *B*.

(4) With the telescope still reversed, unclamp the lower motion and sight on the rear station.

(5) Reverse the telescope on its horizontal axis (turn it right side up), unclamp the upper motion, sight again on the forward station and record the readings of both verniers.

(6) Compute the deflection angle by finding the differences of the vernier readings. If the transit is in adjustment, two values of the deflection angle should differ by not more than 1 minute. The value of the deflection angle should be taken as the mean of at least two readings.

**72. Transit traverse.**—*Q.* Describe the procedure of making a transit traverse. *A.*—

(1) Set up the transit with its plumb bob over a station whose coordinates are known, and which is at one end of a line whose azimuth is known and along which a point can be sighted. Call the transit position station 1.

(2) Measure the deflection angle between the orienting line and the next point at which the transit is to be set up (station 2).

(3) Measure with a tape or chain the distance from station 1 to station 2. Check the distance as thus measured with a stadia reading when possible.

(4) Set up the transit at station 2. Using station 1 as a back sight on which to orient, measure the deflection angle formed by the lines station 2-1 and station 2-3.

(5) Measure the distance station 2-station 3 and check by stadia.

(6) Set up at station 3 and continue the procedure until the gun position is reached.

(7) Whenever possible, close the traverse; that is, using the gun position as a station, continue by another route back to station 1.

*Q.* What is the personnel of a traverse party?—*A.* Instrument man in charge, a recorder, two chainmen, and two rodmen. In case of necessity the rear chainman may also be front rodman and the instrument man can keep his own notes.

*Q.* How are the readings recorded? *A.*—

(1) Rule up seven columns in a notebook.

(2) Column 1 contains names of stations and distances to the next succeeding station.

(3) Columns 2 and 3 contain readings of verniers *A* and *B*, respectively.

(4) Column 4 contains the mean or average readings.

(5) Column 5 contains the computed deflection angle.

(6) Column 6 contains the computed azimuth.

(7) Column 7 contains remarks and compass bearings which should be taken from time to time.

(8) Columns 1 to 4 and 7 are filled in as the readings are taken. The others may be filled in after the traverse is completed. The following is a sample of record sheet:

TRAVERSE FROM BM 7 ( $x=726939.2$ ) ( $y=1582611.0$ ) TO GUN POSITION

| (1)<br>Station and distance (feet)            | (2)<br>Vernier A | (3)<br>Vernier B | (4)<br>Mean | (5)<br>Deflection angle | (6)<br>Azimuth | (7)<br>Remarks                |
|---|------------------|------------------|-------------|-------------------------|----------------|-------------------------------|
|   | ° ' "            | ° ' "            | ° ' "       | ° ' "                   | ° ' "          |                               |
| Azimuth BM to station 1 <sup>1</sup> .        |                  |                  |             |                         | 115 24 30      |                               |
| Station 1—1,200                               | 316 53 30        | 136 53 30        | 316 53 30   |                         |                |                               |
|   | 275 07 00        | 95 07 30         | 275 07 15   | 41 46 15                | 73 38 45       |                               |
|   | 233 22 00        | 53 22 00         | 233 22 00   | 41 45 15                | 73 39 45       |                               |
|   |                  |                  |             | — — —                   |                |                               |
|   |                  |                  |             | —41 45 45               |                |                               |
| Station 2—1,900                               | 233 22 00        | 53 22 00         | 233 22 00   |                         |                |                               |
|   | 279 05 00        | 99 05 00         | 279 05 00   | 45 43 00                | 119 21 45      | Magnetic bearing S. 54°45' E. |
|   | 324 48 00        | 144 48 00        | 324 48 00   | 45 43 00                | 119 23 45      |                               |
|   |                  |                  |             | — — —                   |                |                               |
|   |                  |                  |             | +45 43 00               |                |                               |
| Station 3—2,250                               | 324 48 00        | 144 48 00        | 324 48 00   |                         |                |                               |
|   | 342 08 00        | 162 08 00        | 342 08 00   | 17 20 00                | 136 41 52      |                               |
|   | 359 28 00        | 179 28 30        | 359 28 15   | 17 20 15                | 136 44 52      |                               |
|   |                  |                  |             | — — —                   |                |                               |
|   |                  |                  |             | +17 20 07               |                |                               |
| Station 4—1,500                               | 359 28 00        | 179 28 30        | 179 28 15   |                         |                |                               |
|   | 11 03 30         | 191 03 30        | 191 03 30   | 11 35 15                |                |                               |
|   | 22 39 00         | 202 39 00        | 202 39 00   | 11 35 30                | 148 17 14      |                               |
|   |                  |                  |             | — — —                   |                |                               |
|   |                  |                  |             | +11 35 22               |                |                               |
| Azimuth station 4 to station 5 <sup>2</sup> . |                  |                  |             |                         | 148 21 15      |                               |
| Station 5 <sup>3</sup>                        | 22 39 00         | 202 39 00        | 22 39 00    |                         |                |                               |
|   | 17 38 00         | 197 38 00        | 17 38 00    | 5 01 00                 |                |                               |
|   | 12 38 00         | 192 38 00        | 12 38 00    | 5 00 00                 | 143 20 45      |                               |
|   |                  |                  |             | — — —                   |                |                               |
|   |                  |                  |             | —5 00 30                |                |                               |

<sup>1</sup> BM No. 7 is back sight for station 1. Distance BM No. 7 to station 1 is 870 feet. The azimuth, BM to station 1, is computed from astronomical observations.

<sup>2</sup> Azimuth, station 4 to station 5, is computed from astronomical observations.

<sup>3</sup> Foresight at station 5 was taken on the gun. Distance station 5 to gun is 23 feet.

## SECTION V

### INDICATION AND IDENTIFICATION OF TARGETS

|                                    | Paragraph |
|------------------------------------|-----------|
| Classes and types of aircraft..... | 73        |
| Missions of aircraft.....          | 74        |
| Naval aircraft.....                | 75        |
| Characteristics of airplanes.....  | 76        |
| Indication of targets.....         | 77        |

**73. Classes and types of aircraft.—Q.** What are the two general classes of aircraft?—A. Heavier-than-air and lighter-than-air.

Q. Name the general types of lighter-than-air aircraft.—A. Observation balloons and dirigible airships.

Q. What are the general types of airships?—A. Nonrigid, semi-rigid, and rigid.

Q. What are the heavier-than-air aircraft generally called?—A. Airplanes or aeroplanes, seaplanes, flying boats, and amphibians.

Q. What are the general types of combat airplanes used by the U. S. Army? A.—

- (1) Pursuit.
- (2) Bombardment.
- (3) Reconnaissance, observation, and liaison.
- (4) Transport.

Q. How are pursuit airplanes classified? A.—

- (1) Interceptor.
- (2) Single-place fighter.
- (3) Multiplace fighter.

Q. How are bombardment airplanes classified? A.—

- (1) Heavy.
- (2) Medium.
- (3) Light.

**74. Missions of aircraft.**—Q. What is the normal mission of pursuit airplanes?—A. The interception, attack, and destruction of enemy aircraft in the air.

(1) The interceptor is usually a single-seater with one or two powerful engines.

(2) The single-place fighter is used for escort and patrol in addition to normal pursuit missions.

(3) The multiplace fighter is used for escort and patrol duty near important objectives and against ground-troop formations.

Q. What are the normal missions of heavy and medium bombardment airplanes?—A. To carry heavy bomb loads to great distances for attack of material objectives, and also to conduct long-range, strategic reconnaissance over land and sea.

Q. What are the normal missions of light bombardment airplanes?—A. Light bombardment airplanes (formerly designated as attack) are designed to attack objectives of light construction, routes of communication, airdromes, troop movements, and concentrations of troops in the open or under light shelter. The light bombardment airplane is the striking element of combat aviation which operates in direct support of ground forces. Identification of this type of airplane is especially important to ground troops.

Q. What are the normal missions of reconnaissance, observation, and liaison airplanes?—A. They gather information of the enemy.

The two latter types operate in conjunction with their own forces, performing fire-adjustment missions for artillery, maintaining contact with front lines and marching columns, and carrying on other command, liaison, and courier missions.

**Q.** What are the missions of transport airplanes?—**A.** Transport airplanes are not strictly a combat type of airplane. They are used for the transportation of personnel and supplies. Their importance is rapidly increasing when one considers the transportation of air-landing troops, parachute troops, and important supplies.

**75. Naval aircraft.**—**Q.** What types of airplanes are employed by the Navy, and to what types of Army airplanes do they correspond? **A.**—

(1) Scouting-observation airplanes corresponding to observation airplanes.

(2) Fighter airplanes corresponding to pursuit airplanes.

(3) Torpedo-bombardment airplanes corresponding to bombardment airplanes.

(4) Patrol airplanes which do not correspond to any special type of Army airplane. The Navy has no type of airplane corresponding to the Army light bombardment airplane.

**Q.** Does the Navy make more extensive use of the biplane type of airplane than the Army?—**A.** Yes. They are used on carriers and on board other types of warships, being launched from catapults. They are used for this purpose because they are more stable in flight at low air speeds than monoplanes.

**Q.** What are seaplanes and flying boats?—**A.** They are airplanes equipped with floats (pontons) or boat-shaped hulls instead of wheels, so that they may alight on water. Seaplanes have floats while flying boats have hulls.

**Q.** What is an amphibian airplane?—**A.** It is an airplane having a boat-shaped hull, and also equipped with wheels (that can be pulled up when operating on water) so that it can alight or take off from either a land or water surface.

**76. Characteristics of airplanes.**—**Q.** Why is it important that ground personnel be familiar with the appearance in flight, method of operation, and characteristic sounds of airplanes?—**A.** These factors are the means by which airplanes are identified and indicated.

**Q.** What are the basic flight positions used for ready recognition of airplane types? **A.**—

(1) Coming flight or front view.

(2) Passing flight or side view.

(3) Flight at lower altitude or top view.

(4) Overhead flight or bottom view.

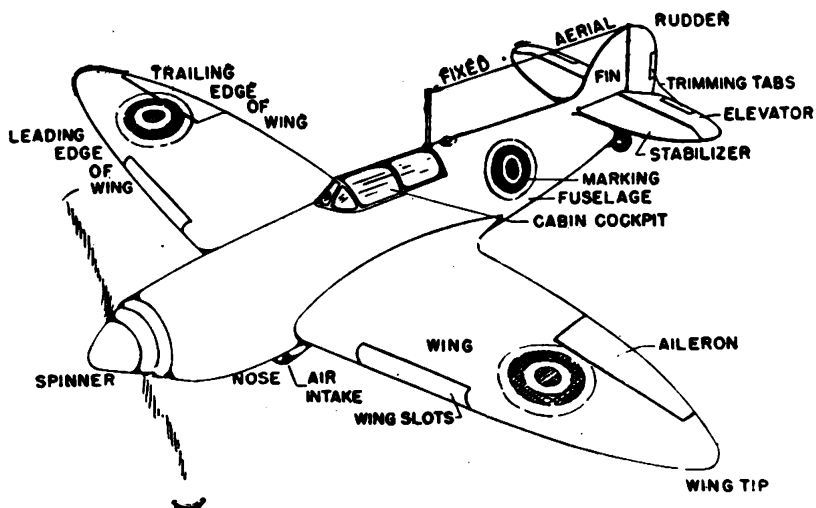


FIGURE 46.—Nomenclature of airplane parts.

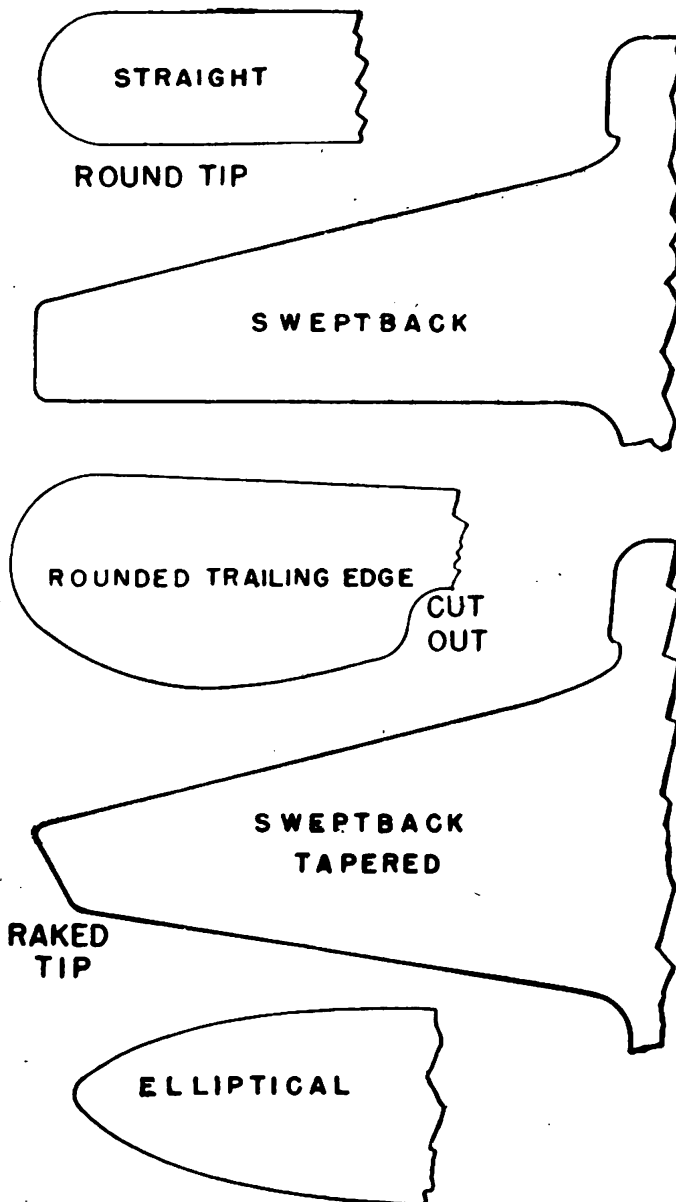


FIGURE 47.—Wing shapes.

(5) Maneuvering flight or perspective view.

Q. What is meant by coming flight or front view?—A. All positions of flight in which only a general head-on view of the airplane may be had.

Q. What is meant by passing flight or side view?—A. All positions of flight in which the side of the fuselage, vertical fin, and rudder are the major surfaces presented to view.

Q. What is meant by flight at lower altitude or top view?—A. All positions of flight in which the upper sides of wings, fuselage, and horizontal tail surfaces are the major surfaces presented to view.

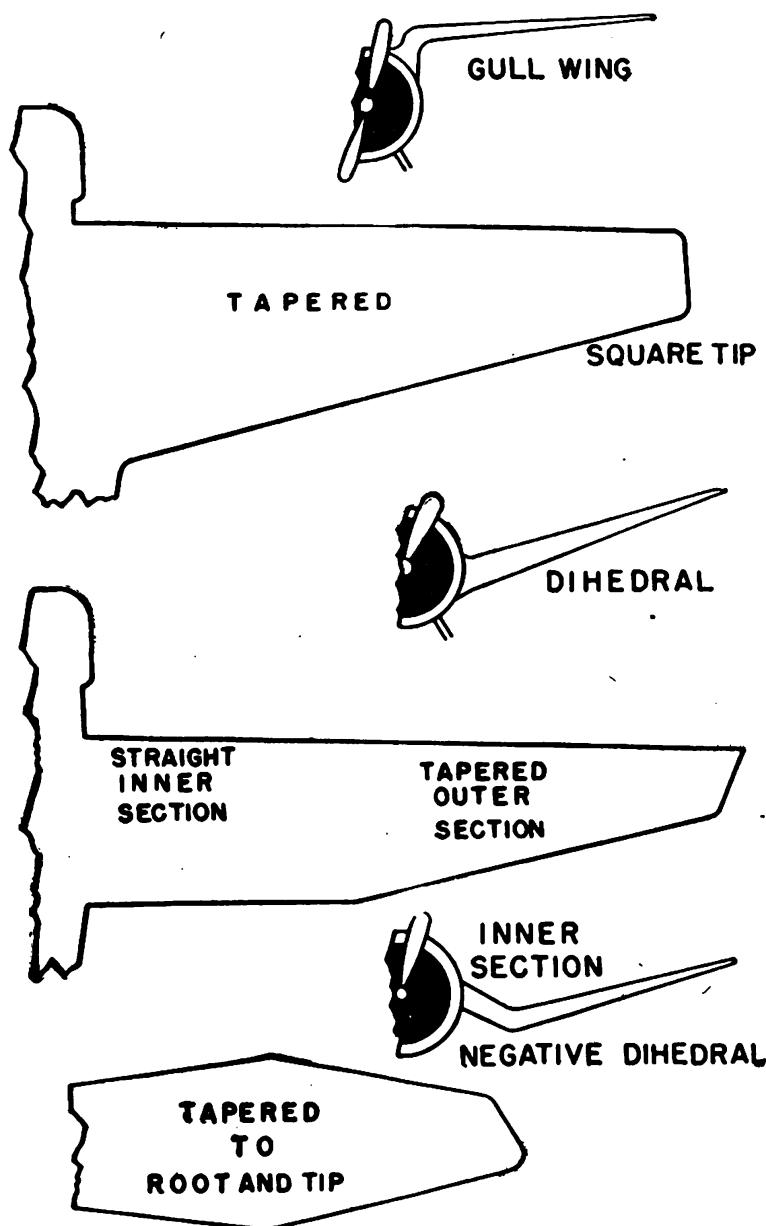
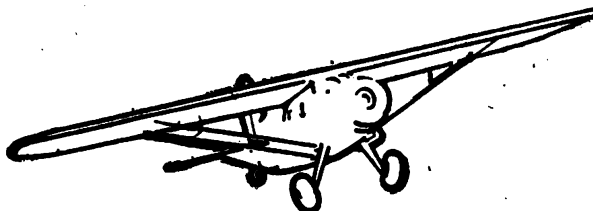


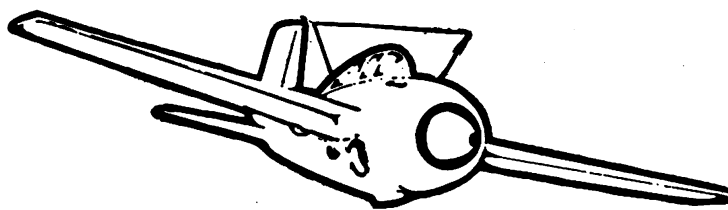
FIGURE 47.—Wing shapes—Continued.

**Q.** What is meant by overhead flight or bottom view?—**A.** All flight positions in which the under sides of wings, fuselage, and horizontal tail surfaces are presented to view.

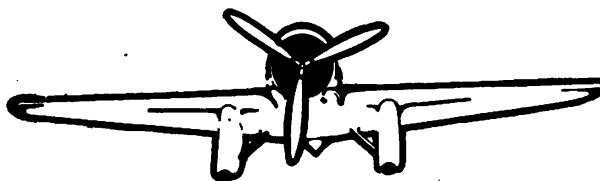
**Q.** What is meant by maneuvering flight or perspective view?—**A.** All flight positions which are different from straight and level flight. It includes banking, turning, climbing, diving, and combinations of such maneuvers. The airplane may present, momentarily at least, nearly all of the views presented under other conditions of flight.



HIGH-WING



MIDWING



LOW-WING

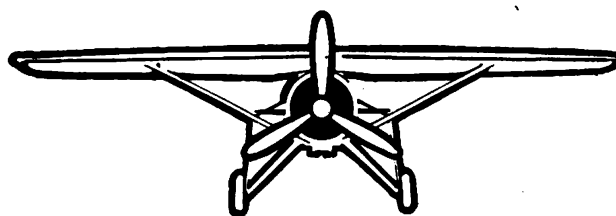
**(PARASOL MONOPLANE)**

FIGURE 48.—Monoplanes.

**Q.** What characteristics of outline of the airplane are most readily seen in overhead flight? **A.**—

(1) *Shape of wing.*—The general shape and proportion of wings, as long and narrow, short and stubby.

(2) *Type and shape of nose.*—Nose extends much or little in advance of leading edge of wings; that is, plane is long-nosed or short-nosed.

(3) *Length and shape of fuselage.*—Compare the relatively short fuselage of the small- and medium-sized airplanes with the long, slender, streamlined appearance of the larger types.

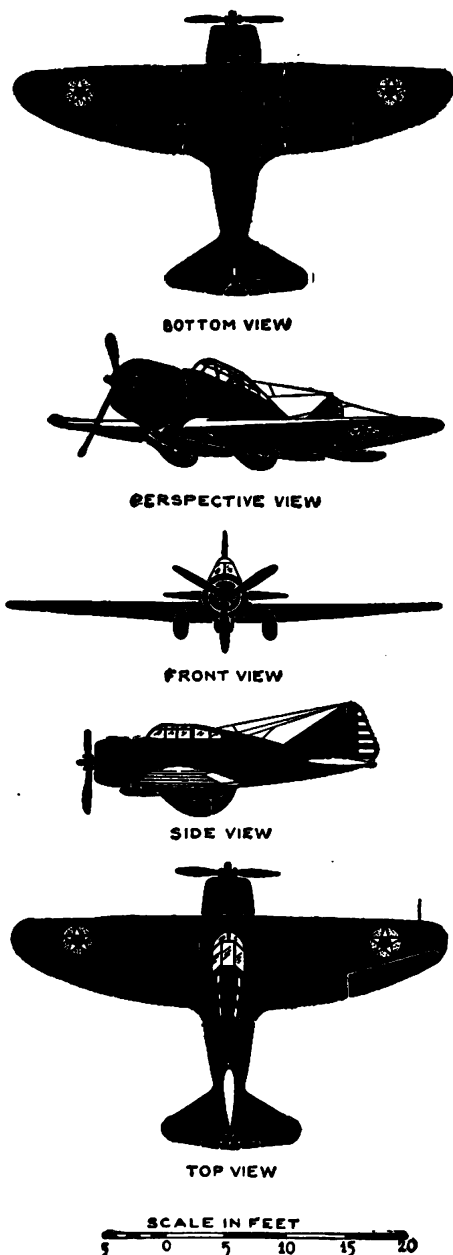


FIGURE 49.—Pursuit USA P-35.

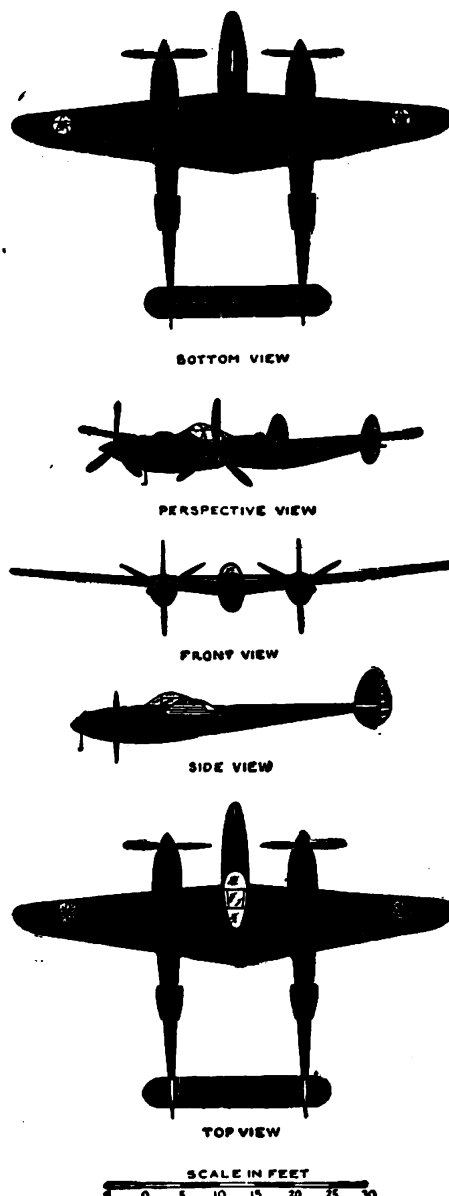


FIGURE 50.—Pursuit USA P-38.

(4) *Location and number of engines.*—In single-engined airplanes the engine is located in the nose and by its type determines the shape of the nose; that is, with radial engines the nose is blunt and stubby,

while with in-line and V-type engines the nose is more slender and pointed. In multiple-engined airplanes the engines are usually housed in nacelles extending from the leading edge of the wings. In the unusual pusher types, the engines extend from the trailing edge of the wings. Even at great altitudes when the number of engine nacelles cannot be exactly determined, their presence will give an un-

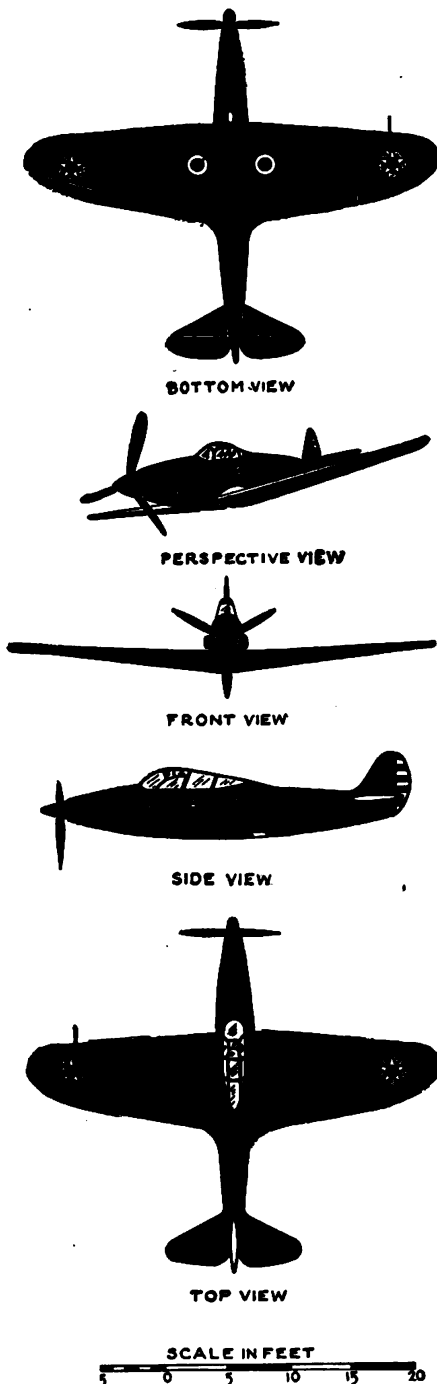


FIGURE 51.—Pursuit USA P-39, P-39A, P-39C

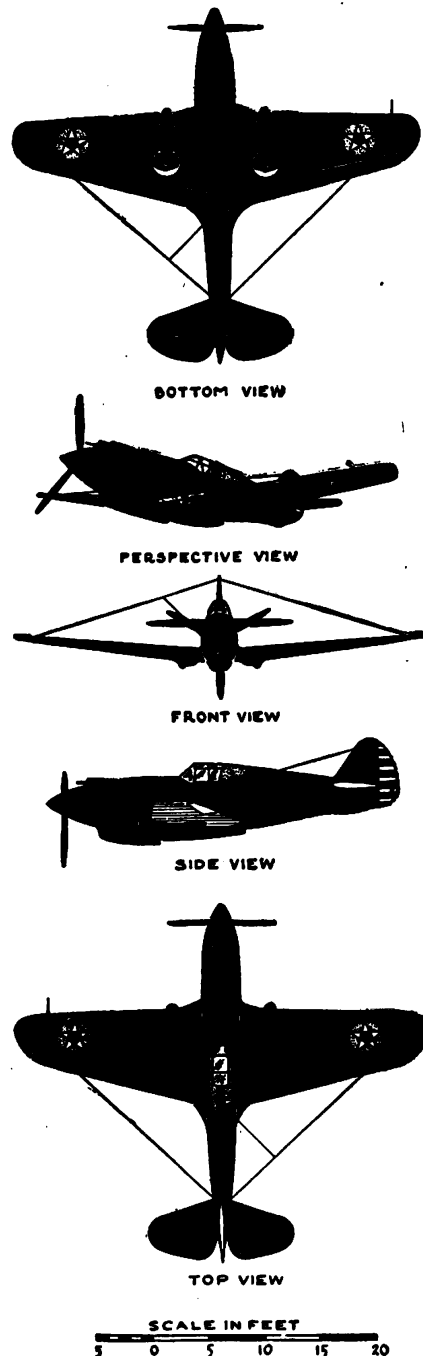


FIGURE 52.—Pursuit USA P-40.

mistakable irregular outline to the wings warranting identification as multiple-engined.

(2) *Shape of nose.*—It may be slender and pointed, blunt and stubby, smoothly rounded, or shark-nosed.

(3) *Size of vertical fin and rudder.*—Note the relative size of the vertical fin and rudder compared to the fuselage.

*Q.* What characteristics of outline are most readily seen in passing flight? *A.*—

(1) *Shape and outline of fuselage.*—It is short and chunky in smaller pursuit types; elongated and streamlined in larger types; long and thick bodied in larger bombardment types. Note outline being broken by such parts as cockpits, canopies over cockpits, and gun turrets.

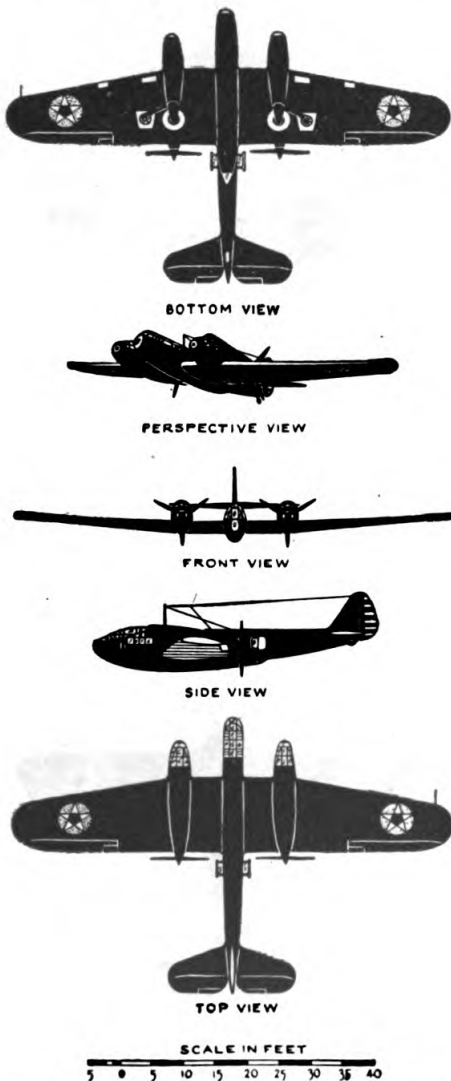


FIGURE 53.—Multiplace fighter USA YFM-1.

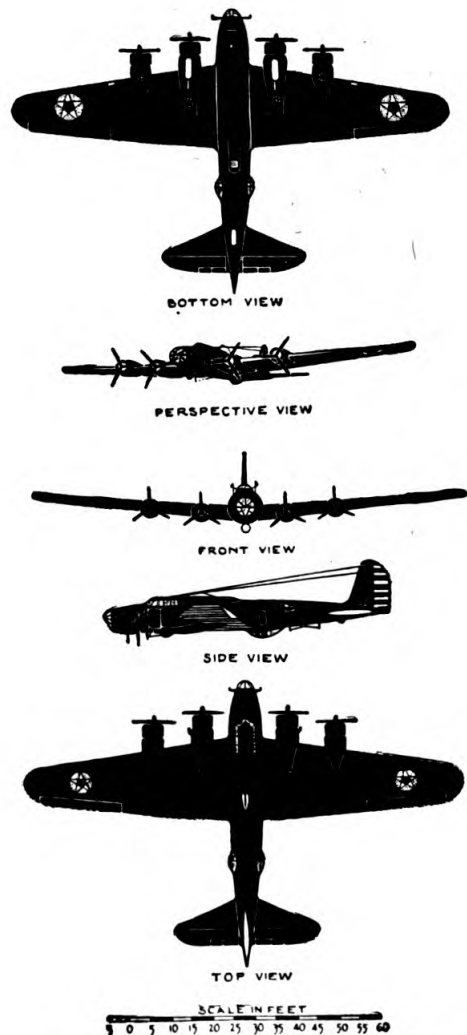


FIGURE 54.—Bombardment USA B-17, B-17A, B-17B.

Q. What characteristics of outline are most readily seen in coming or going flight? A.—

(1) *Relationship of wings to fuselage.*—Has high-wing, mid-wing, low-wing, or parasol-wing types; dihedral angle pronounced, moderate, or practically zero.

(2) *Number of engines.*—The irregularity of outline of wings will indicate a multiple-engined type.

(3) *Features of vertical tail members.*—It is usually possible to identify single- and double-rudder types.

(4) *Undercarriages.*—Nonretractable landing gear is usually plainly visible.

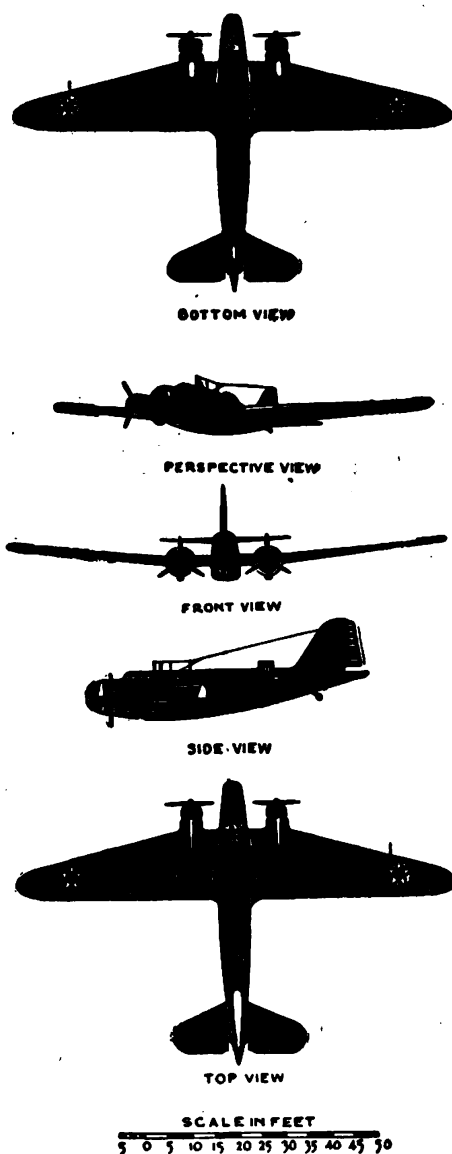


FIGURE 55.—Bombardment USA B-18.

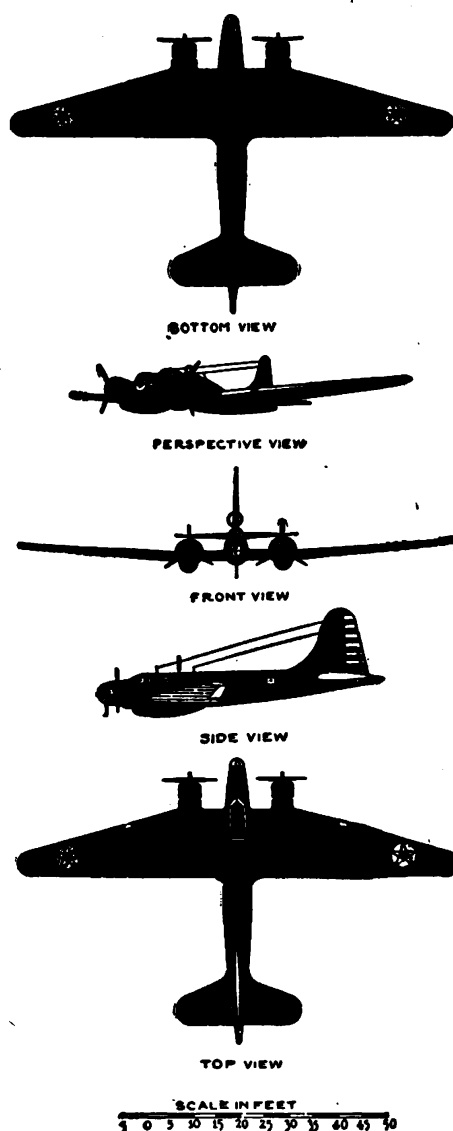


FIGURE 56.—Bombardment USA B-23.

*Q.* What characteristics of outline are most readily seen in maneuvering flight?—*A.* All the features previously pointed out may be momentarily visible.

*Q.* What characteristic methods of operation of pursuit assist in its identification?—*A.* Pursuit normally operates in formation with the squadron of 18 airplanes as the largest group operating as a unit. An observer noting one such formation should look below, to the front, above, and to the rear of it for other units.

*Q.* What characteristic methods of operation of heavy and medium bombardment assist in its identification?—*A.* They operate in column of three-plane elements (route column) with successive elements

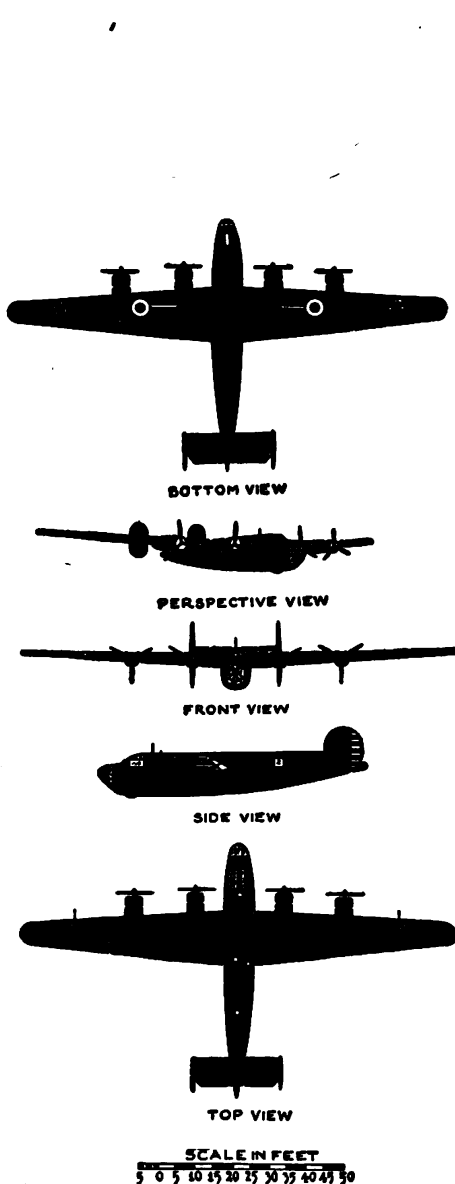


FIGURE 57.—Bombardment  
USA B-24, B-24A.

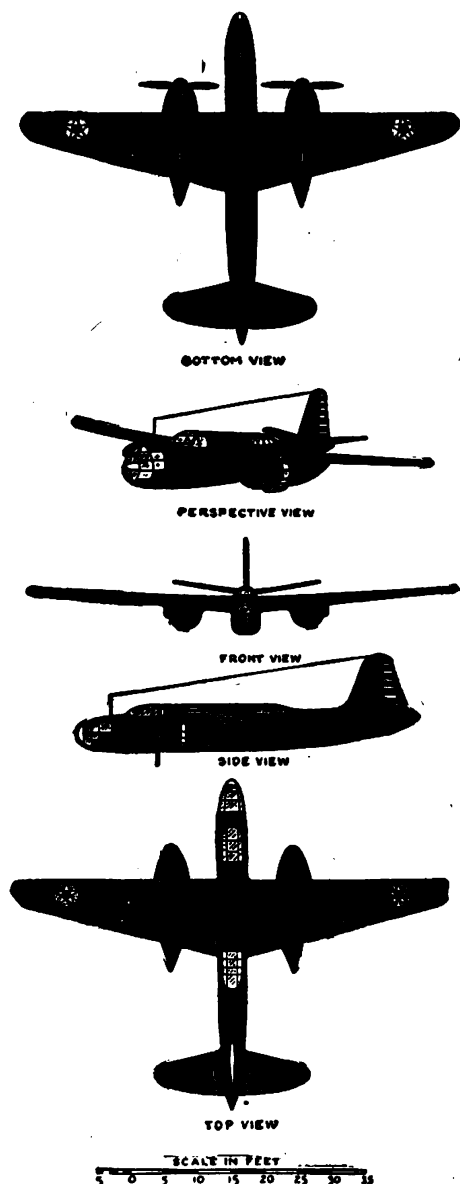


FIGURE 58.—Light bombardment USA  
A-20, A-20A.

stepped up or down from front to rear. They usually fly straight courses at medium or high altitude unless attacked from the air or by anti-aircraft fire.

Q. What characteristic methods of operation assist in the identification of light bombardment?—A. They operate in formation at minimum or medium altitudes. They use the three-plane element

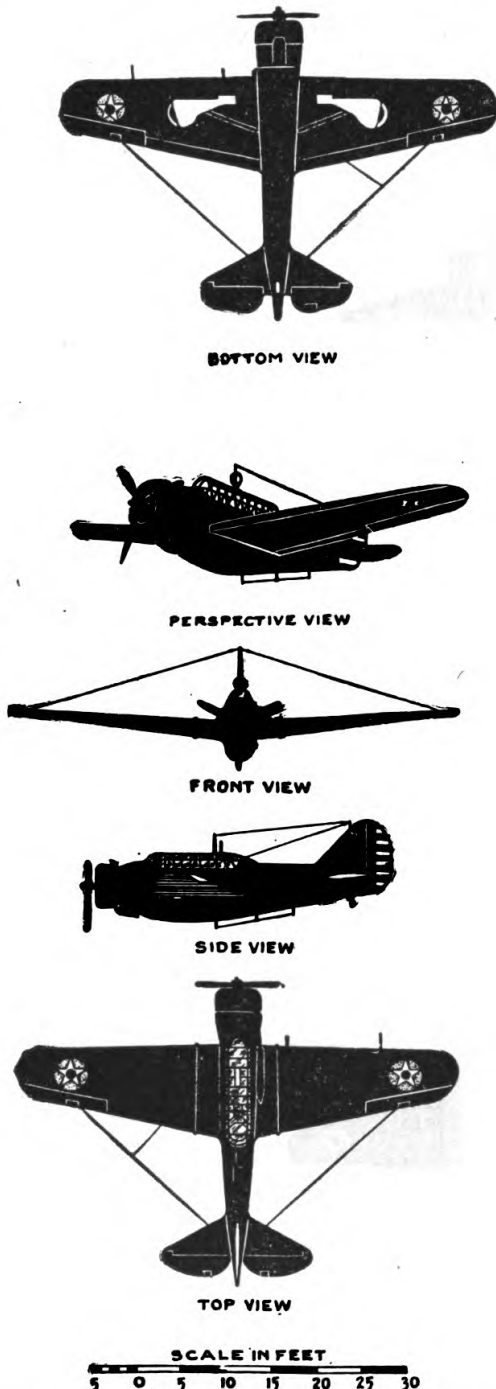


FIGURE 59.—Observation USA O-47A, O-47B.

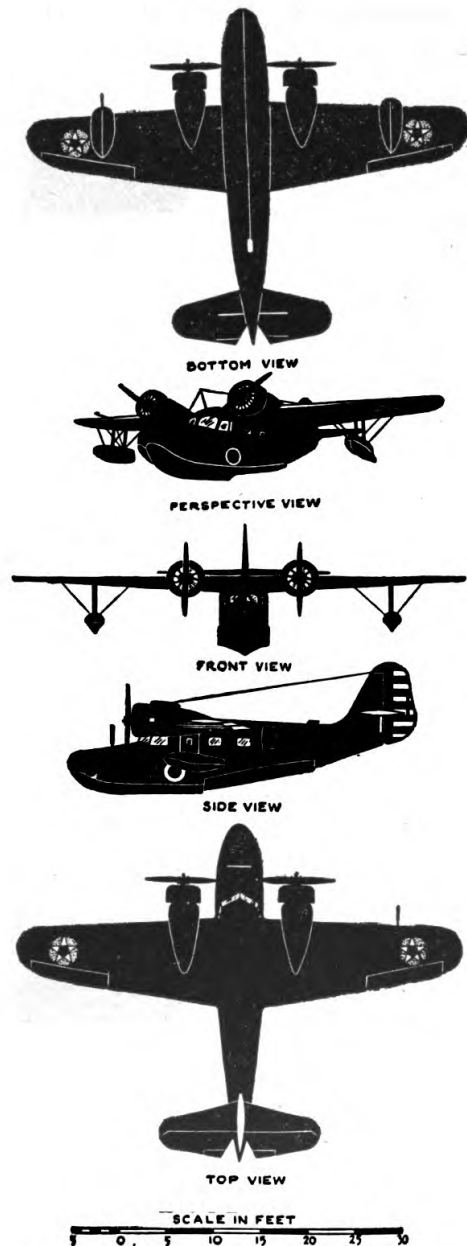


FIGURE 60.—Observation amphibian USA OA-9.

echeloned to the rear at approximately the same altitude. The normal operating unit is the squadron of nine airplanes with the largest formation the group of three squadrons. This type of aviation supports the operations of ground troops.

*Q.* What characteristics of operation of reconnaissance airplanes assist in their identification?—*A.* They operate at any altitude from low to high, usually operate singly, and fly straight courses unless attacked. Bombardment airplanes may perform long-range reconnaissance.

*Q.* What characteristic methods of operation assist in identification of observation and liaison airplanes?—*A.* They operate almost en-

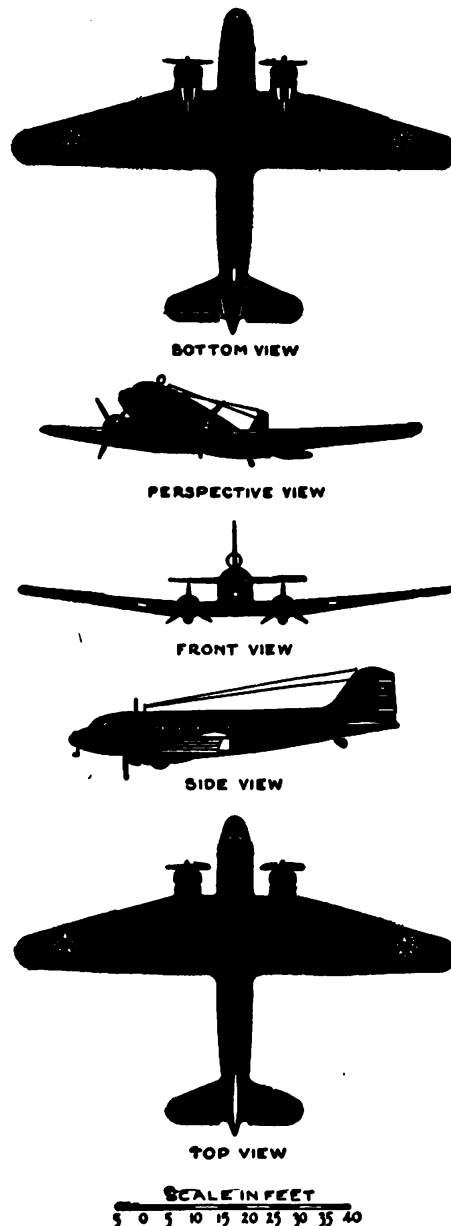


FIGURE 61.—Transport USA C-38, C-39, C-41, C-41A, C-42.

tirely within own lines, fly singly on various courses at low and medium altitudes, and will be seen circling over own troops and troop columns to drop messages and observe panels.

*Q.* What are some of the characteristic sounds of pursuit airplanes in flight?—*A.* Pursuit airplanes in flight are characterized by sounds of fast rhythm, high pitch, moderate volume, and by extreme variations in pitch and tone while maneuvering.

*Q.* What are some of the characteristic sounds of heavy and medium bombardment airplanes while in flight?—*A.* They have a fairly deep pitch, a moderately heavy volume, and a steady tone and rhythm.

*Q.* What are some of the characteristic sounds of light bombardment airplanes while in flight?—*A.* They have a heavy volume of sound due to low altitude, and a fairly deep pitch, with tone and rhythm steady but varying considerably when maneuvering.

**77. Indication of targets.**—*Q.* State, in the order in which given, what information is given and the terms used in indicating aircraft during daylight. *A.*—

(1) Designation of the reporting station by name or number.

(2) Number of airplanes, when they can be counted. If they cannot be counted the word "several" or the word "many" may be used.

(3) Type of airplane, such as observation, pursuit, etc., when they can be identified. In other cases the word "airplane" is used.

(4) Altitude, in general terms as follows: very low (below 500 yards); low (500 to 2,000 yards); medium (2,000 to 5,000 yards); or high (over 5,000 yards).

(5) Location, by the sector in which or toward which the aircraft are flying.

(6) Direction of flight, by one of the eight points of the compass: north, northeast, east, southeast, south, southwest, west, and northwest.

*Q.* State which of these elements of information are given in indicating aircraft at night.—*A.* Designation of reporting station, number of airplanes (one, several, or many), altitude, and location.

## SECTION VI

### GENERAL DUTIES OF OBSERVERS

General duties of observers..... Paragraph 78

**78. General duties of observers.**—*Q.* What is the purpose of an observation post?—*A.* To observe and report all enemy activity, particularly to give warning of approaching hostile aircraft. Also to identify approaching friendly planes so troops are not needlessly disturbed.

Q. What are some important considerations in selecting an observation post? A.—

- (1) Tactical location favorable for securing information.
- (2) Unobstructed field of view.
- (3) Concealment and shelter.
- (4) Accessibility for establishing communications.
- (5) Supply of food and water for the detail.

Q. What equipment is necessary?—A. Field glasses, compass, maps or charts, message forms, and a telephone. Spare batteries and an extra telephone should be provided if available.

Q. What training should the detail have? A.—

(1) Particular training in identification of both friendly and enemy planes or formations.

(2) Use and care of the field telephone.

(3) Sending of flash messages.

Q. What particular training should the chief of detail have? A.—

(1) Map reading, use of compass, and following route on a map.

(2) Ability to select locations for observation posts.

(3) Training in operation and care of telephones and in installing lines of communication.

(4) Protection and rationing of detail, maintenance of discipline, and keeping of records.

Q. What records are usually kept?—A. Copies of all flash messages and other reports sent in. Flash messages received need not be recorded as they are only for aiding the observing detail. The intelligence officer may also have special charts and reports to be kept for which he will give special instructions.

Q. What points should the chief of detail watch? A.—

(1) That the observers on duty divide the sector for observation.

(2) That they keep each other awake while on duty.

(3) That accurate information is reported.

Q. How is information obtained at night?—A. At night the observer must depend on his sense of hearing. This makes it essential that the observation post be in a quiet location. Positive identification is usually impossible, though the type of plane or formation may often be determined by its sound. Frequently identification can be made from outlying observation posts through the aid of the searchlights, before it can be done at the units themselves.

Q. What is a listening post?—A. A night observation post established by searchlight units to report on approaching aircraft and supply information for directing the searchlights.

## SECTION VII

## OPERATION OF ANTIAIRCRAFT SPOTTING SET

|  | Paragraph |
|--|-----------|
| Operation and maintenance of theodolite equipment..... | 79        |
| Time-interval device, type PH-35.....                  | 80        |
| Time-interval device, type PH-103.....                 | 81        |
| Installation of theodolites.....                       | 82        |
| Developing film.....                                   | 83        |
| Projector equipment, type PH-40.....                   | 84        |
| Film viewer, type PH-97.....                           | 85        |

**79. Operation and maintenance of theodolite equipment.—**

**Q.** Upon what does analysis of effectiveness of antiaircraft fire depend?—**A.** Upon the accurate determination in three dimensions of the positions of the bursts with respect to the target.

**Q.** What is camera spotting?—**A.** The photographing of the target and bursts by two synchronized motion-picture cameras, or recording theodolites, set up at the ends of a surveyed base line.

**Q.** May this method of spotting be used for adjustment of fire? Why?—**A.** No. The target and bursts are photographed, and deviations are not available until the film is developed.

**Q.** Where are the two cameras located with respect to the battery positions?—**A.** One camera is at the battery, the other from 3,000 to 5,000 yards on the flank, at the end of an accurately surveyed base line.

**Q.** What type motion picture camera or recording theodolite is used?—**A.** Three types of recording theodolites are now in service: types PH-BA-33 and PH-BB-33, manufactured by the Akeley Camera Company, and type PH-BC-33, manufactured by the Mitchell Camera Corporation.

**Q.** What precautions should be taken when handling the theodolite? **A.—**

(1) The theodolite should always be transported in its carrying chest.

(2) The theodolite should never be dropped or handled roughly.

(3) No adjustments should be attempted except under the supervision of an officer familiar with the equipment.

(4) The theodolite should always be held in place by the clamp provided in the carrying chest.

(5) When removing it from the case or in handling, lift the theodolite by means of the lifting handle and balance it with the other hand under the main body of the instrument. Never attempt to lift by pressure on the telescope or other moving parts.

*Q.* How are the cameras mounted for use?—*A.* They are mounted on previously prepared pier mounts. Tripods are not furnished with the cameras.

*Q.* Is there any difference between the battery ( $O_1$ ) camera and the flank ( $O_2$ ) camera?—*A.* No. They are identical.

*Q.* What is the first step in mounting a camera?—*A.* Have available a pier mount with adapter securely fastened. The base ring is secured to the adapter plate by means of three standard-thread bolts. If a flange-topped pier mount is available, bolts with wing nuts may be used.

*Q.* Must the base ring be exactly level?—*A.* No. Although a level base ring will make leveling the theodolite easier, the level screws on the base of the instrument are designed to correct for minor deviations in base ring level.

*Q.* How is the theodolite fastened to the base ring?—*A.* After the azimuth to the orienting point has been set on the counters, the theodolite is locked to the base ring by means of the azimuth clamp.

*Q.* What are the steps in orienting a theodolite? *A.*—

(1) By means of the traversing handwheel, set the azimuth to the orienting point on the azimuth counters.

(2) Next, by grasping the base of the theodolite below the leveling screws, turn the entire instrument to place the telescope vertical cross hair on the orienting point.

(3) Remove parallax from the eyepiece and focus the telescope.

(4) Grasp the base and set the vertical wire exactly on the orienting point, tightening the azimuth clamp so that the theodolite base cannot rotate on the base ring. No attempt should be made to rotate the theodolite on its base ring by pressure on the upper carriage. Such action places too great a strain on the traversing gears.

(5) Level the theodolite by means of the leveling screw.

(6) Traverse back to the orienting point and check the azimuth setting.

*Q.* How is the theodolite leveled?—*A.* There are four leveling screws and two spirit levels. Set the theodolite so that the level bubbles are along the line of two opposite leveling screws. In the type PH-BC-33 theodolite the bubbles follow the motion of the left thumb; in types PH-BA-33 and PH-BB-33 the bubbles follow the right thumb. Continue adjusting each set of opposite screws until bubbles remain centered throughout 360° traverse.

*Q.* How many mils change in azimuth and elevation are there per revolution of the traversing and elevating handwheels, respectively?—*A.* One revolution of the traversing or elevating handwheel changes the azimuth or elevation 40 mils.

**Q.** In addition to the photograph of target and projectile bursts, what other data are recorded by the theodolite?—**A.** Azimuth and angular height of target and time.

**Q.** How are these data recorded?—**A.** These data appear within the camera on Veeder type counters which are photographed on the edge of each film frame.

**Q.** How are the counters photographed?—**A.** The counters are illuminated by a lamp in the 12-volt circuit. Light reflected from the counters passes through two right-angle prisms and an inverting lens, casting an image which is photographed on one edge of the film which is not exposed to light entering the main camera optical system.

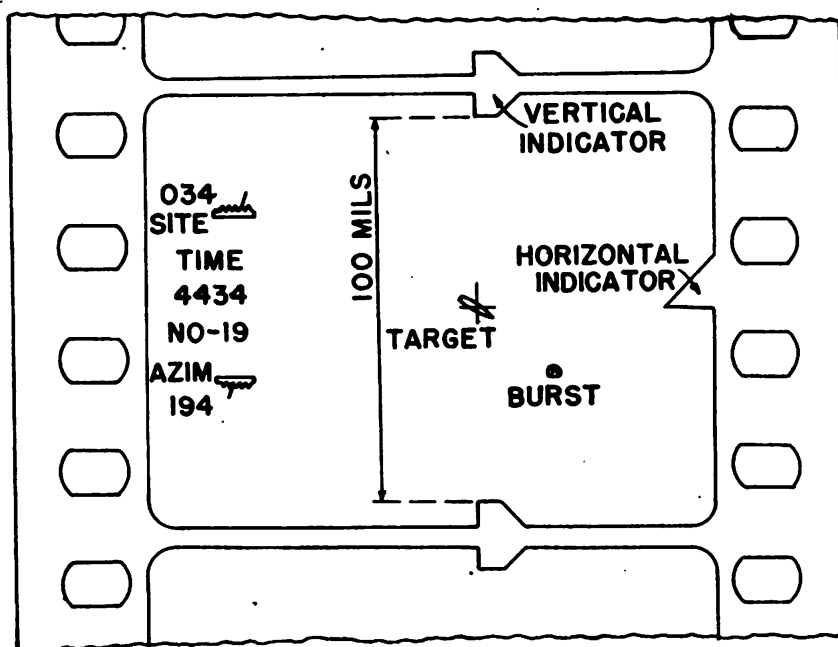


FIGURE 62.—A frame of exposed film.

**Q.** How many sets of azimuth and angular height counters are there on a theodolite?—**A.** There are two sets of azimuth counters and two sets of angular height counters. One of each is internal, to be photographed, and the others are external, for the convenience of the observer.

**Q.** Can the internal counter be checked against the external counters without developing the film?—**A.** Yes, they can be observed through the internal counter window.

**Q.** What readings appear on the angular height counters?—**A.** Angular height counters read from 0 to 1,600 mils when elevating from horizontal to the vertical and 1,600 to 3,200 mils when the line of sight is rotated beyond the vertical down to horizontal.

*Q.* What readings appear on the azimuth counters?—*A.* The azimuth counter readings increase from 0 to 9,999 mils as the theodolite is traversed clockwise.

*Q.* Since there are 6,400 mils in a circle, why do the azimuth counters read up to 9,999 instead of to 6,400 before returning to zero?—*A.* The commercial Veeder type counter (0 to 9,999) is used rather than undergo the added expense of manufacturing special counters with a maximum reading of 6,400 mils. One complete revolution from zero with the azimuth counter set at zero will register 6,400 mils on the counter.

*Q.* What special features of construction have the internal azimuth and elevation counters?—*A.* The tens, hundreds, and thousands digits appear as ordinary numerals in the counter window. The units digit is replaced by a line marker which rides horizontally along a saw-toothed scale from left to right. The crests of the teeth represent the odd mils 1, 3, 5, 7, and 9; the troughs, the even mils 2, 4, 6, 8, and 0. This line-marker device is designed to permit reading of elevation and azimuth to the nearest mil and at the same time avoid a blur in the photograph of the units digit numerals which would result during rapid operation of the handwheels if a conventional units digit were used.

*Q.* What are the least readings on the external and internal azimuth and elevation counters?—*A.* The least reading on the external counters is 0.2 of a mil and on the internal azimuth and elevation counters is 1 mil.

*Q.* An azimuth reading of 100 mils may appear on the azimuth counters as what two readings?—*A.* An azimuth reading of 100 mils may appear on the azimuth counters as 100 mils or 6,500 mils.

*Q.* A reading on the azimuth counters of 7,592 indicates what azimuth?—*A.* An azimuth of 1,192 mils.

*Q.* How is this azimuth obtained?—*A.* It is obtained by subtracting 6,400 mils from 7,592 mils.

*Q.* When the azimuth counters read 0195 mils what is the azimuth?—*A.* The azimuth may be either 195 mils or 3,795 mils, obtained by adding 10,000 to reading and subtracting 6,400 from result.

*Q.* What may an azimuth reading of 3,795 indicate?—*A.* If the actual azimuth pointing of the theodolite is in error, the above reading may indicate that the theodolite has been traversed clockwise through zero azimuth twice and is set at azimuth 995; or that the instrument has been traversed counterclockwise through zero once and is set at azimuth 195.

*Q.* What action can be taken to insure that the reading of the azimuth counters is the correct azimuth and thus eliminate compu-

tations?—A. When setting up the camera, make both internal and external azimuth counters read the azimuth to the orienting point. Do not traverse the camera through a complete revolution. When a course is completed, traverse the instrument back to the starting point by traversing in the reverse direction.

Q. An angular height counter reading between 1,600 and 3,200 mils indicates what?—A. Such a reading indicates that the telescope and camera prism have been elevated to the vertical and plunged down toward the horizontal on the other side. In all cases where angular height counter reading is between 1,600 and 3,200 mils, subtract reading from 3,200 for true angular height.

Q. For what purpose is another counter, in addition to azimuth and elevation counters, required in the theodolite?—A. Another counter is needed in the theodolite to indicate time interval for the

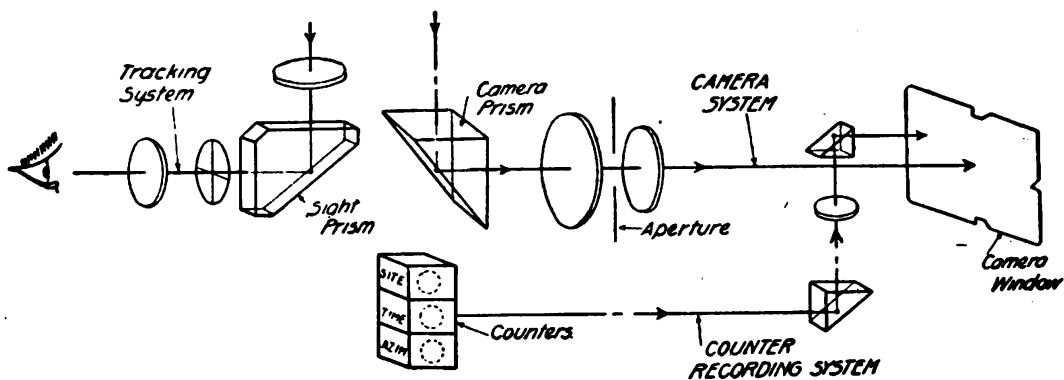


FIGURE 63.—Optical system for theodolite.

purpose of synchronizing records of the two theodolites used in each spotting set. This counter is located between the internal elevation and azimuth counters, and no external time counter is provided. The time counter also reads from 0 to 9,999 (usually seconds), but the tens digit appears as a numeral instead of a line marker as in the other internal counters.

Q. What other data appear on the film besides azimuth, angular height, and time?—A. The camera number also appears on the film.

Q. Why is it important to have the camera number photographed on each film?—A. So that the film can be positively identified as having been exposed in a certain camera.

Q. How many optical systems are needed? What are they?—A. Three optical systems are needed, one for the tracking telescope and two for the camera. The extra system in the camera is required to photograph the counters.

Q. What is the field of view of the tracking telescope?—A. The field of view of the tracking telescope on the type PH-BC-33 theodolite is 156 mils; for other types, 50 mils.

Q. The camera in the theodolite always remains level, with the optical axis of the camera lens in a horizontal plane, while photo-

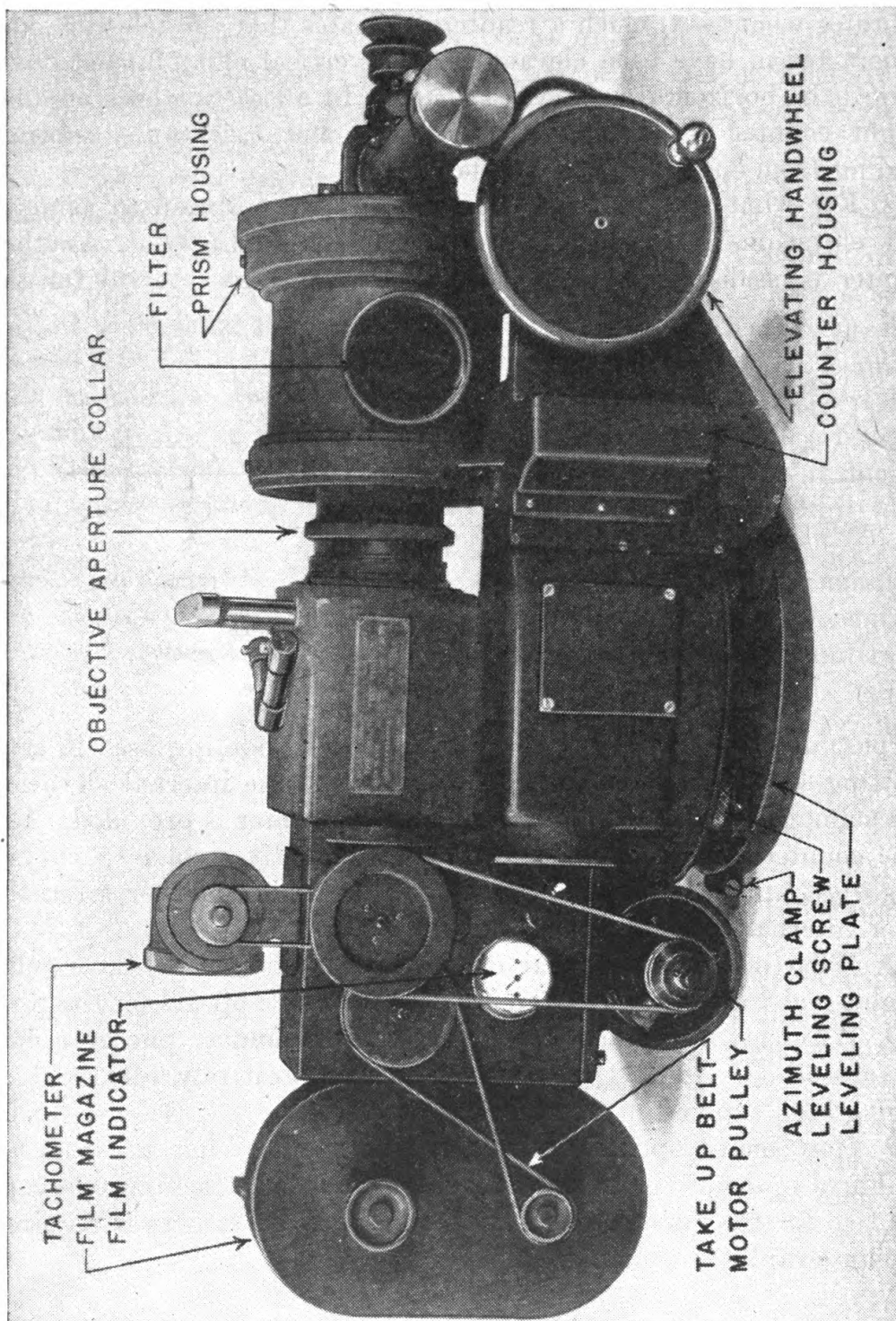


FIGURE 64.—Theodolite (front view).

graphing high-angle targets. How is this accomplished?—A. Directly before the camera objective lens, a right-angle reflecting prism is mounted in such a manner that it may be rotated in angular height about the horizontal optical axis of the camera lens. The tracking telescope is mounted so as to rotate with the prism and point in the same direction. This movement of telescope and prism in angular height is controlled by the elevation handwheel while, at the same time, the entire camera may be rotated in azimuth to point at the target. Parallel light rays from the objects photographed enter through the filter window and are turned 90° by the prism to pass into the camera lens.

Q. What change occurs in the photograph when the instrument is elevated?—A. The image of the main field rotates with respect to the horizontal and vertical indicators by an amount equal to the angular height of the target.

Q. In photographs taken with the spotting camera, right and left sides of the picture are reversed but top and bottom are not reversed. What causes this result?—A. The right-angle prism reverses rights and lefts but does not invert the image.

Q. What is the extent of the camera photographic field?—A. The camera has a field of 100 mils, measured between the horizontal edges of the vertical indicators.

Q. How is the camera operated in following the target?—A. In tracking a target, the observer keeps the target at the intersection of the telescope cross hairs by means of the elevating and traversing handwheels.

Q. Why do the cross hairs not intersect in the tracking telescope of the type PH-BC-33 theodolite?—A. The intersection is eliminated in order to keep the center of the field clear so that a target is not lost behind the cross hairs.

Q. What drives the film-feed mechanism?—A. A 12-volt d-c motor mounted on the camera drives the film-feed mechanism through spring-belt driven pulleys in the type PH-BA-33 theodolite, and through a gear train in other types.

Q. How is the lower or take-up bobbin in the magazine operated?—A. The take-up bobbin is operated by the camera motor through a series of spring-belt driven pulleys.

Q. The take-up bobbin in the camera magazine of the theodolite PH-BC-33 is designed to take up film over the top of the bobbin. The other two types of theodolite are designed to take up the film as it passes under the bobbin. How may the latter type cameras be operated so as to take up the film over the top of the bobbin?—A. By

crossing the spring belt so as to operate the bobbin pulley in the opposite direction. Take-up has proved to be more positive in the theodolite PH-BA-33, when film passes over the lower bobbin.

Q. Which of the two pulleys on the magazine should be used in the theodolite PH-BA-33?—A. The take-up bobbin will operate more positively if the two pulleys on the magazine are interchanged; that

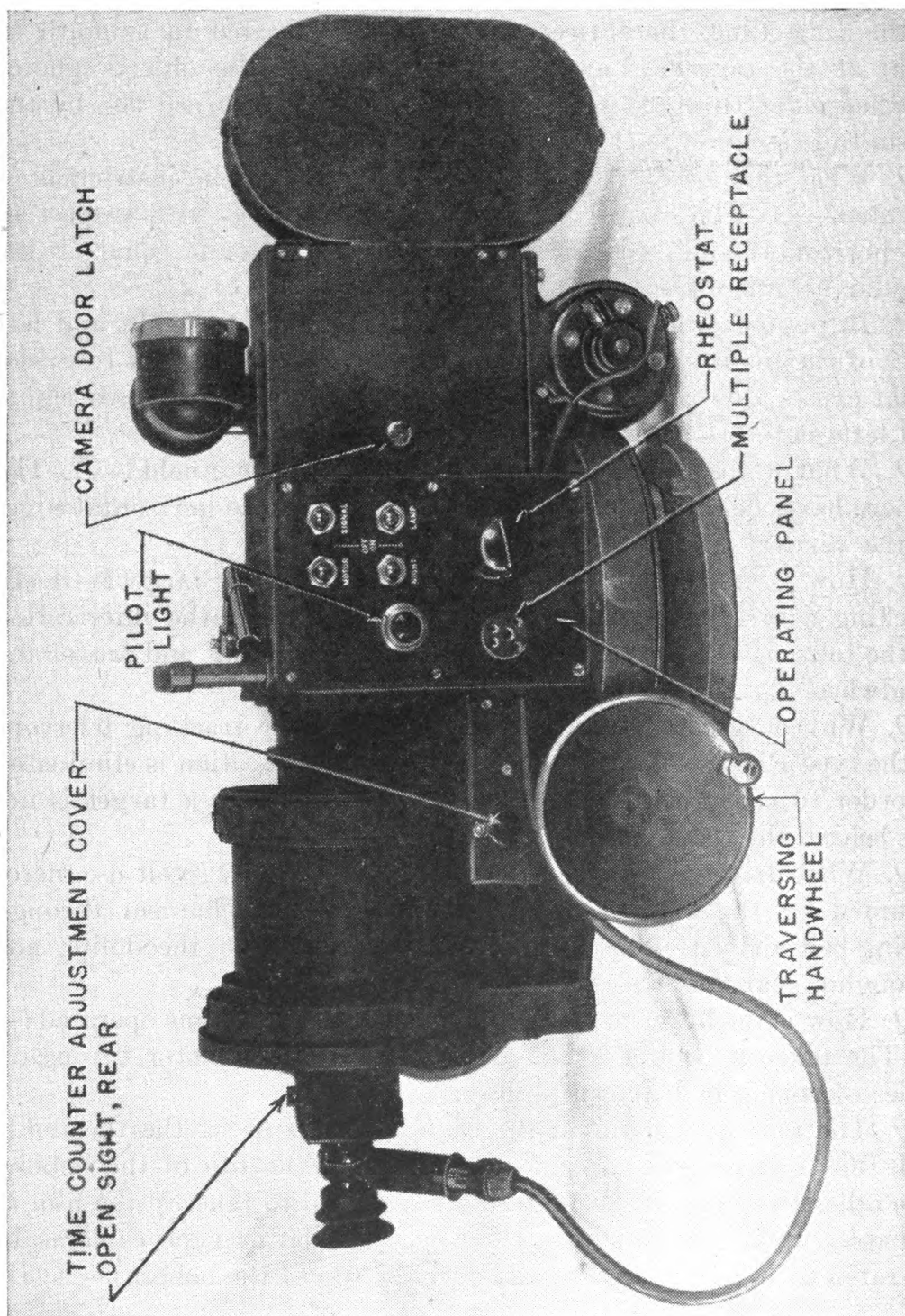


FIGURE 65.—Theodolite (rear view).

is, if the large pulley is removed from the upper spindle and placed on the lower spindle. These pulleys may be removed by withdrawing the taper pin located in the spindle within the magazine.

*Q.* Which of the two motor pulleys is used for day operation of the theodolite PH-BA-33?—*A.* The small motor pulley is used for day operation. The small pulley drives the film feed mechanism slower than the large pulley and thus permits film-operating speeds as low as 10 frames per second even when the 12-volt batteries are fully charged.

*Q.* What is the operating panel?—*A.* A rectangular plate composed of a nonconducting material on the rear of the theodolite. On this panel are mounted four switches: lamp, night, signal, and motor switch; a four-way receptacle; a red signal lamp; and the motor rheostat.

*Q.* What does each switch on the panel control?—*A.* The lamp switch controls the lamp which illuminates the internal counters; the signal switch controls the time-interval device circuit which actuates the time counters and red signal lamp; the night switch controls the background and the telescope reticle lights; and the motor switch is used for starting and stopping the camera motor. In the theodolite PH-BC-33, the motor switch also turns the counter lamp on and off with the motor.

*Q.* How many men are required at each theodolite and what are their duties?—*A.* Three men are required at each theodolite.

- (1) *Operator.*—(a) Loads film.
- (b) Interchanges magazine on camera.
- (c) Controls speed of film feed mechanism.
- (d) Reads exposure meter.
- (e) Sets camera aperture.
- (f) Controls signal and motor switches.

(2) *Observer.*—(a) Orients and levels the instrument.

(b) Tracks the target, keeping it centered at the intersection of the cross hairs by operation of the azimuth and elevation handwheels.

(3) *Recorder.*—(a) Keeps a record showing the following information:

1. Date.
2. Time.
3. Place (whether O<sub>1</sub> or O<sub>2</sub>).
4. Serial number of camera (located below internal time counter).
5. Names of recorder, operator, and observer.
6. Designation of firing battery.

(b) For each course—

1. Serial number of course.
2. Time counter readings at beginning and end of each course.
3. Position of sun with reference to theodolite.
4. Type of sky background.
5. Exposure meter reading. (Value indicated by galvanometer needle.)
6. Film emulsion speed.
7. Type of light filter.
8. Filter factor.
9. Frames per second shown by tachometer.
10. Aperture setting.

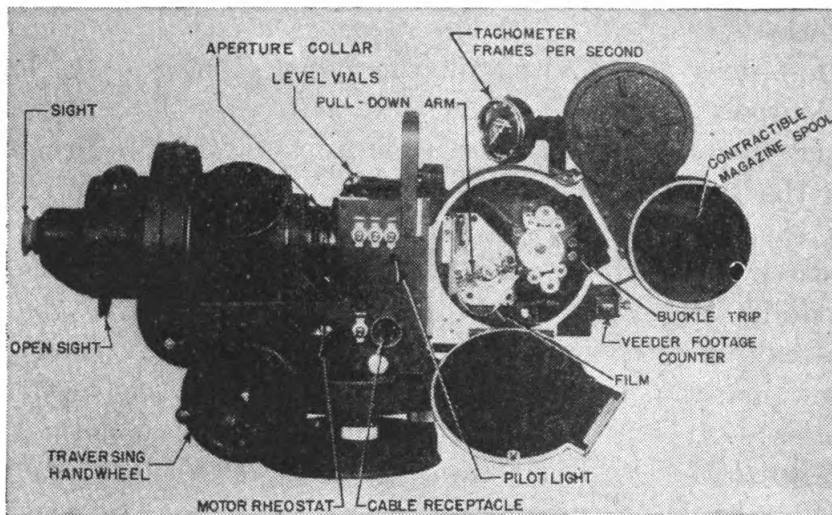


FIGURE 66.—Recording theodolite, PH-BC-33.

11. Number of rounds fired on course.

12. Remarks covering anything unusual.

Q. How is the operation of the theodolites controlled? A.—

(1) The battery ( $O_1$ ) theodolite is the control theodolite. At the command "Stand by for time zero, ready, take," the  $O_1$  operator starts the time counters in both theodolites by throwing the signal switch.

(2) As the target approaches the safe field of fire, this operator cautions "Stand by" and this command is transmitted by telephone to  $O_2$ .

(3) Just before the first burst occurs, as determined by the time of flight of that round, the  $O_1$  operator commands CAMERA ACTION and turns on both the motor and counter lamp. The  $O_2$  operator receives this command by telephone and takes similar action.

(4) After the last burst occurs, the  $O_1$  operator commands OUT OF ACTION and both operators stop cameras. The  $O_1$  operator also stops the time counters to allow the recorders to obtain a record of last time. After checking to see that both  $O_1$  and  $O_2$  time counters read the same, the counters are advanced to an even hundred before the start of the next course.

Q. When should the operator notify the officer in charge as to the amount of film remaining in the magazine?—A. Before a practice starts so that, if there is insufficient film, a new magazine may be installed to obviate the necessity of holding fire to change magazines after a practice has started.

Q. What checks should be made before and after each practice?—A. Pick a well-defined object at least 200 yards distant, lay the theodolite accurately on the point, and take a few feet of film. Traverse through 3,200 mils and "dump" the telescope, traverse back to the reference point, and take a few feet of film. When projected, any slipping in azimuth or lack of level will be discovered and deviations corrected a like amount.

Q. How may practices be identified other than by counter numbers as photographed?—A. By photographing identification panels before and after each practice.

Q. What kind of film is used?—A. Film used is 35-millimeter commercial panchromatic moving-picture film.

Q. In what length rolls is film furnished?—A. The film used comes in 200-foot (60-meter) rolls, each roll sealed in a tin box.

Q. What is panchromatic film?—A. Film which is sensitive to all colors, including red.

Q. How is the camera loaded? A,—

(1) *Theodolite PH-BA-33*.—(a) Open the camera door.

(b) Attach a loaded magazine to the camera box by means of the two magazine locking lugs.

(c) Remove the gate by swinging it to the rear and lifting it from its hinges.

(d) Withdraw enough film from the upper bobbin to fill the gate recess.

(e) Replace the gate and turn the camera driving pulley until the feeding fingers freely engage the perforations in the film.

(f) Press the upper roller forward and insert the film between it and the sprocket, making sure the film perforations are engaged by sprocket teeth. Do the same with the lower roller. Enough film should be left at the top and bottom of the gate to prevent binding but not so much as to allow film to rub against the camera box.

(2) *Theodolite PH-BC-33*.—(a) Open the camera door.

(b) Attach a loaded magazine to the camera box by means of the groove and catch.

(c) Release the rollers from the driving sprocket wheel by rotating the two knurled heads on which are mounted one pin each.

(d) Withdraw enough film from the upper bobbin to thread over the sprocket, through the film gate, and back under the sprocket.

(e) Rotate the wheel on the rear of the camera until the film pull-down claws have been moved as far as possible from the film guides below the film gate.

(f) Thread the film in the film gate by holding the film guides, which are nearer to the camera lens, in the open position. Release the film guides so that the film is properly positioned.

(g) Thread the film under the sprocket and around the guiding rollers. Close the top and bottom sprocket rollers and rotate the handwheel until the pull-down claws have engaged the perforations.

(h) Check, by rotating the motor flywheel, to see that the slack in the film is sufficient to operate the camera but not so much as to permit rubbing on the camera box. Such rubbing will cause scratching. The length of loop has been indicated by a white line inside the camera box.

(i) Set the buckle-trip mechanism, which is between the sprocket and the take-up magazine, by pulling the control knob until the buckle-trip is in position. In case the take-up mechanism does not operate, this buckle trip will be forced open by slack film and turn off the camera motor.

(j) Attach the spring to the take-up pulley on the rear of the magazine.

(k) Close the camera door. If the camera door will not close, it indicates that the rollers over the sprocket have not been returned to the operating position.

*Q.* Where is the film loaded into the magazine?—*A.* The film is loaded into the magazine either in a darkroom or in the changing bag. Total darkness is required since panchromatic film is sensitive to all colors.

*Q.* How is the film placed in the magazine? *A.*—

(1) *Theodolite PH-BA-33.*—Remove the magazine cover. In absolute darkness remove the film from its container and remove the small, wooden bobbin on which the film is wound; then insert in the roll the upper bobbin of the magazine. This operation may require the removal of several inches of film from the center of the roll to make room for the magazine bobbin. For magazines not provided with an upper bobbin, the wooden bobbin received in the film roll

is utilized. The bobbin is placed so that the film feeds off the bottom, emulsion side up. The end of the film is led out of the magazine through the upper slit and back in through the lower slit. The end is then placed under the spring clip on the lower bobbin in such a manner as to reel the film over the top of the bobbin. Take up six or seven turns on the bobbin, place it on the upper spindle, and close and lock the magazine cover. The magazine is now loaded, and ready for use.

(2) *Theodolite PH-BC-33*.—Remove the covers from the top and bottom of the magazine. In total darkness place the roll of unexposed film on the spindle in the top magazine with the film paying off the bottom of the roll, emulsion side up. The end of the film is threaded through the upper slit of the magazine and back through the lower slit. Remove the collapsible spool from the take-up spindle in the bottom part of the magazine far enough to allow the spool to collapse. Thread the film through the slit in the collapsible spool. Replace the collapsible spool on the spindle. This operation clamps the film on the spool. Turn the take-up pulley on the magazine until two or three turns have been reeled on the take-up spool, passing over the top of that spool. Replace the covers on the top and bottom of the magazine. The magazine is now loaded and ready for use.

Q. When loading the magazine in the camera, from which bobbin is taken the slack film for threading?—A. The slack always is taken from the upper bobbin, since that is the unexposed film.

Q. What is shutter speed of the camera?—A. Shutter speed is the length of time the camera shutter remains open while admitting light for a single exposure. Shutter speed depends on the speed of the camera motor. At 10 frames per second, shutter speed is approximately one twenty-first of a second; at 16 frames, one thirty-fourth of a second. On the theodolite PH-BC-33, the shutter speed for various frames per second is indicated on the tachometer dial.

Q. What does shutter speed one-twentieth second mean?—A. As each frame of the film is directly opposite the aperture and lens, the shutter opens for one-twentieth of a second, allowing light rays to touch the sensitive negative film.

Q. What effect has the use of a filter on the aperture setting?—A. Since a filter reduces the amount of light reaching the film, it is necessary either to lengthen the time of exposure or to enlarge the aperture. In operation of the theodolite camera the number of frames per second usually is kept the same during daylight, and the amount of light reaching the film is varied by adjustment of the aperture.

*Q.* What adjustment of the camera is made to compensate for changes in light conditions?—*A.* The size of the aperture must be varied under different conditions of light.

*Q.* How is the camera objective focused?—*A.* The camera focus is locked at infinity and cannot be adjusted.

*Q.* What is the purpose of filters?—*A.* Filters are used to produce on the negative greater contrast between the sky background and the images of target and bursts.

*Q.* What is a filter factor?—*A.* A filter factor is a number which is used in calculating the proper aperture setting to be used in obtaining correct exposures. The filter factor, when divided into the emulsion speed of the film used, gives the number which should be set on the emulsion speed dial of the exposure meter.

*Q.* What type filters are used on the theodolite camera?—*A.* The theodolite, type PH-BA-33, is provided with the Wratten filter number 29 F. The theodolite, type PH-BC-33, is provided with four Wratten filters:

| <i>No.</i> | <i>Name</i>                                |
|------------|--|
| 5N5        | Aero No. 2, with neutral density (yellow). |
| 25         | A (tricolor red).                          |
| 29         | F (red).                                   |
| 39         | Duplicating (blue).                        |

*Q.* Under what conditions should each of the filters be used? What is the proper filter factor to be used in each instance? *A.*—

| Color of burst | Sky background | Target color | Filter (Wratten designation) | Filter factor |
|----------------|----------------|--------------|------------------------------|---------------|
| White          | White          | Red          | 5N5                          | 12.5          |
| Do             | Blue           | White        | 29 F                         | 8             |
| Do             | do             | Red          | or<br>25 A                   | 5             |
| Black          | White          | do           | 5N5                          | 12.5          |
| Do             | Blue           | White        | 5N5                          | 12.5          |
| Do             | do             | Red          | 39                           | 5             |
|                |                |              | 39                           | 5             |

(The 25 A filter may be used under the same burst-sky-target combination as the 29 F filter when light conditions are less intense as in late afternoon. When photographing high-explosive bursts against a blue sky, if a 39 filter is not furnished, no filter is used and the aperture is increased 1½ stops wider than calculated by the exposure meter.)

*Q.* How is the aperture setting determined?—*A.* The only accurate way is to use an exposure meter. Lacking an exposure meter, aperture setting of  $f5.6$  for poor light or  $f16$  for bright light will ordinarily give fairly good results.

*Q.* How is the aperture setting determined by using the exposure meter?—*A.*

(1) *Exposure meter PH-77 (Weston universal exposure meter).*—Divide the emulsion speed of the film used by the proper filter factor; then set the index of the dial labeled "Emulsion speed" to the quotient obtained. Compute the shutter speed approximately by dividing by two the fraction one over the number of frames per second. Take a light reading and, by rotating the inner dial, set the arrow to the value of that reading. Opposite the shutter speed read the " $f$ " value which is the correct aperture setting.

(2) *Exposure meter PH-77B (Weston Cine exposure meter).*—Divide the emulsion speed of the film used by the proper filter factor; then set the index of the dial labeled "Emulsion speed" to the quotient obtained. Set the type of camera to "A." Set the index pointer, which is located under the emulsion speed reading, to the desired number of frames per second. Take a meter reading while pointing the instrument at that part of the sky which is to be photographed. On the scale of " $f$ " value read the correct aperture setting opposite number in the outer circle obtained from the meter reading.

*Q.* Having determined the proper aperture setting, how is the aperture varied on the camera?—*A.* The proper aperture opening is set by turning the objective aperture collar until the indicator is opposite the desired value.

*Q.* What is the focal length of the camera lens? *A.* The focal length of the camera lens in the theodolites PH-BA-33 and PH-BB-33 is 6.5 inches; for the theodolite PH-BC-33, 6 inches. Provision has been made on the latter type theodolite for mounting a camera lens of 12-inch focal length.

*Q.* What does an aperture setting of four mean?—*A.* A setting of four ( $f4$ ) means that the diameter of the aperture is one-fourth of the focal length of the lens.

*Q.* With bright light conditions, should the aperture be opened or closed?—*A.* The brighter the light, the smaller the aperture opening; the poorer the light, the larger the aperture opening.

*Q.* What is the widest opening possible for the aperture?—*A.* When the aperture diameter is equal to the diameter of the lens.

*Q.* When would a maximum opening of the aperture be justified?—*A.* The maximum opening of the lens aperture is always used for night firing.

Q. When is a filter not used?—A. A filter is not used for night photography.

Q. Why is the night lamp necessary in night operation?—A. The night light, in addition to illuminating the reticle cross hairs, casts the shadow of the centering indicators on the film.

Q. What precautions should be taken in handling an exposure meter?—A. Exposure meters are delicate, expensive equipment. They must not be dropped or jarred. When using, the ribbon should be around user's neck to prevent possible injury due to dropping. When not in use, exposure meters should be kept in a leather or chamois skin case to prevent scratching or breaking the photoelectric cell glass. Prolonged contact with the human body affects accuracy of meter. The meter should be carried in its case. Light from the sun should not be allowed to fall on the lens of the exposure meter.

Q. How many exposure meters are required for a camera set-up?—A. Two exposure meters are required, one at each camera.

Q. Why are two instruments necessary?—A. The light value at one station may be entirely different from that at the other. To obtain light values and aperture setting at one station and telephone them to the other may result in under- or over-exposed films.

Q. How may film-emulsion speed be determined?—A. Film-emulsion speed is obtainable from the manufacturer. Usually the emulsion speed is not printed on the film container. The film emulsion speeds (Weston) for several types of film on the market are as follows:

| Agfa :                | Weston<br>Film speed | Eastman :        | Weston<br>Film speed |
|-----------------------|----------------------|------------------|----------------------|
| Ultra Speed Pan.....  | 100                  | Super XX.....    | 100                  |
| Superpan Supreme..... | 50                   | Plus X.....      | 50                   |
| Finopan .....         | 24                   | Panatomic X..... | 24                   |

Q. What emulsion speed gives the best results?—A. Film with emulsion speeds from 50 to 64 (Weston) gives the best results. Film speed higher than 64 has been found to be inferior for use in anti-aircraft spotting.

Q. Should an attempt be made to adjust the optical or camera prism in the field?—A. Only in case of an emergency, and then under the supervision of an officer.

Q. What is the normal operating speed for day operations?—A. The normal operating speed is 10 frames per second.

Q. How is operating speed controlled?—A. By means of the motor rheostat on the control panel.

Q. What is the normal operating speed for night operations?—A. The camera of the theodolite PH-BA-33 should be operated at 14

to 15 frames per second at night; the camera of the PH-BC-33, at 18 to 20 frames per second. These are maximum practicable speeds.

*Q.* Why must the camera be operated at a faster speed at night than during daytime?—*A.* In night firing, the camera photographs the flash of the burst. Since this flash lasts only a very short time, it is necessary to speed up the camera to insure burst images on more than one frame.

*Q.* What is the purpose of the tachometer?—*A.* The tachometer registers rate of feed of the film in frames per second. On the theodolite PH-BC-33 the tachometer also registers the shutter speed in seconds.

*Q.* What is the purpose of the film footage indicator?—*A.* The footage indicator shows the amount of film used from a roll. It should be set back to zero as each new roll of film is started.

*Q.* What theodolite controls the time counters?—*A.* The battery theodolite controls the counters by means of the signal switch. The signal switch on the flank theodolite is habitually kept closed. Since both solenoids are in series, the battery theodolite signal switch controls the counters in both cameras.

*Q.* When is the signal switch turned on?—*A.* At the command "Time zero, Ready, Take" from the officer in charge of the record section, the operator at the battery theodolite throws the signal switch to "on."

*Q.* Is there any means of determining whether or not the signal circuit is closed?—*A.* Yes, the pilot lamp (red lamp on control panel) flashes each time counters turn over one digit. The final motion of the counter solenoid plunger closes the pilot lamp circuit and energizes the lamp from the 12-volt storage battery circuit.

*Q.* What is the necessity for synchronizing time counters in each instrument before each course?—*A.* Counters are synchronized so that time will correspond on both films and facilitate matching bursts when reading.

*Q.* How are cameras synchronized?—*A.* The counters of the camera having the lowest counter reading are set ahead until both have the same counter reading.

*Q.* How may time counters be advanced?—*A.* Remove the counter adjusting-screw cover on the rear of the theodolite and turn the slotted screw until the counters reach the desired reading. Counters in the theodolite PH-BC-33 also may be advanced by operation of the continuity test key of the time-interval device PH-103.

*Q.* How are the time counters turned to 0000?—*A.* Time counters on all types of theodolites may be turned to 0000 by removing the adjusting-screw cover on the rear of the theodolite and turning the

slotted screw until 0000 is set. An additional method is provided on the theodolite PH-BC-33; by turning a knurled knob on the front of the theodolite, the time counter may be set quickly to 0000.

*Q.* At what reading should time counters be set at the beginning of each course? *Why?*—*A.* Counters should be set at an even hundred at the beginning of each course for two reasons: first it serves to identify the course easily; second, with the time-interval device set at 60 beats per minute, each change of one units digit in the counter represents 1 second of time, and the interval in seconds, since time zero, is read quickly and easily without subtraction from the last two counter digits.

*Q.* What is the purpose of the control box provided with theodolite PH-BA-33?—*A.* It serves as a junction box for connecting the power lines to the theodolite PH-BA-33 through a cable and multiple plug and receptacle on the theodolite operating panel.

*Q.* What lubrication of the theodolite is necessary *A.*—

(1) *Theodolite PH-BA-33.*—The six oilholes inside the camera, three sliding surfaces on the linkage mechanism, and three pulleys on the front of the theodolite should be lubricated with clock oil. Motor grease cups should be filled with vaseline or light cup grease.

(2) *Theodolite PH-BC-33.*—Those places which are indicated in the instruction book should be lubricated with clock oil.

**80. Time-interval device, type PH-35.**—*Q.* What time-interval device is used with the theodolite PH-BA-33?—*A.* The time-interval device PH-35, known as the metronome type, is used.

*Q.* What is the purpose of the time-interval device?—*A.* The time-interval device is used to make and break periodically an electrical contact in the circuit controlling the time counters.

*Q.* How is the metronome or time-interval device, type PH-35, operated?—*A.* The clock spring is wound up by means of the key. The adjusting weight is placed at the 60-beat indicator on the pendulum shaft. Fill the three contact cups with mercury, using an eyedropper. The center cup is filled to such level that the wire is always in contact with the mercury. The other two cups are filled to such level that the wire breaks contact with the mercury in one cup at each end of its swing. Start the pendulum swinging and calibrate the pendulum to exactly 60 beats per minute.

*Q.* Is there an alternate method for putting the metronome in service?—*A.* Yes, fill the center and one end cup with mercury. Place the adjusting weight at the 120-beat indicator.

*Q.* What is the advantage of the alternate method?—*A.* The metronome will maintain a more uniform beat with little danger of

the contact wires dragging mercury up and hence failing to break contact, which results in failure of the counters to turn over.

*Q.* Where should the metronome be placed for most satisfactory operation?—*A.* In a level spot away from the effect of the concussion of gunfire, preferably at the flank station.

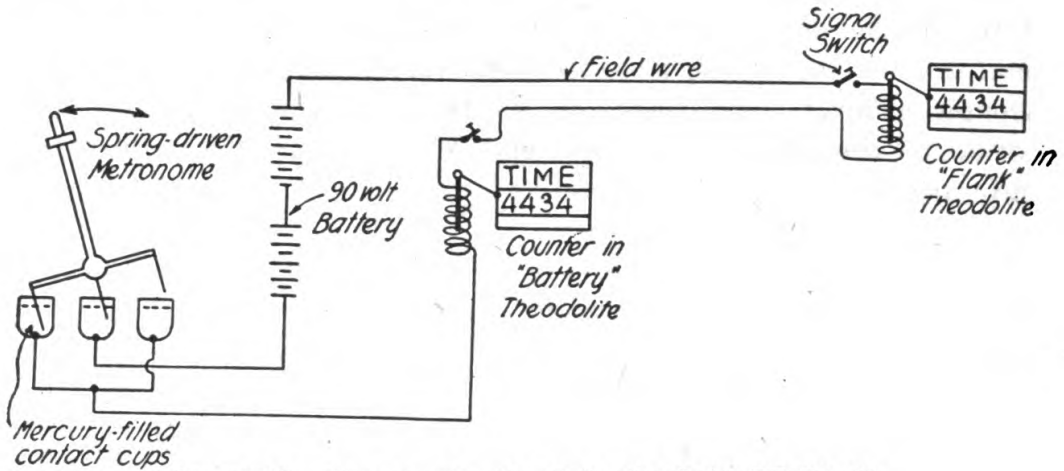


FIGURE 67.—Time counter circuit for theodolite PH-BA-33.

*Q.* What precaution must be taken with the metronome?—*A.* The spring must not be allowed to run down. The pendulum should be checked frequently for calibration as to beats per minute. Avoid jarring or tipping. Contact wires, mercury cups, and surface of mercury in the cups must be kept clean and free from mercury oxide, since mercury oxide is a poor conductor of electricity.

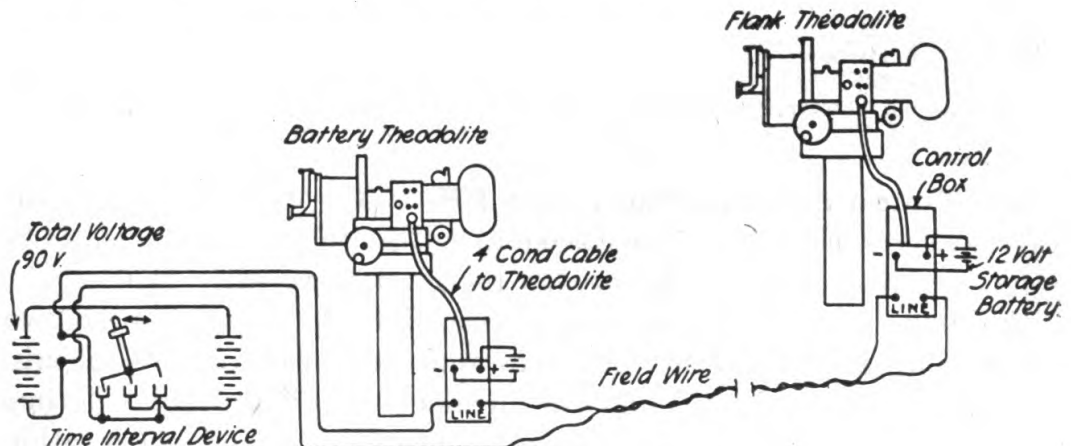


FIGURE 68.—Electrical connections for theodolite PH-BA-33.

*Q.* What is the minimum current which will operate the time counters?—*A.* Thirty-five milliamperes.

*Q.* How does the metronome affect the operation of the time counters?—*A.* One terminal of the two 45-volt batteries in the metronome is connected to the center contact cup. The other terminal is

connected to the two other contact cups after passing through two switches and two solenoids, one in each theodolite. As the pendulum swings to one side, contact is made between the center and one outside contact cup, completing the circuit and causing current to flow. As the pendulum swings to the other side, contact is made between the center cup and opposite side, causing current to flow through the circuit in the same direction. The current flows through the time counter solenoid. Each time the solenoid is energized, the plunger, through a lever and gears, moves the counters ahead one unit. Motion of the plunger near the end of its stroke closes the signal lamp circuit.

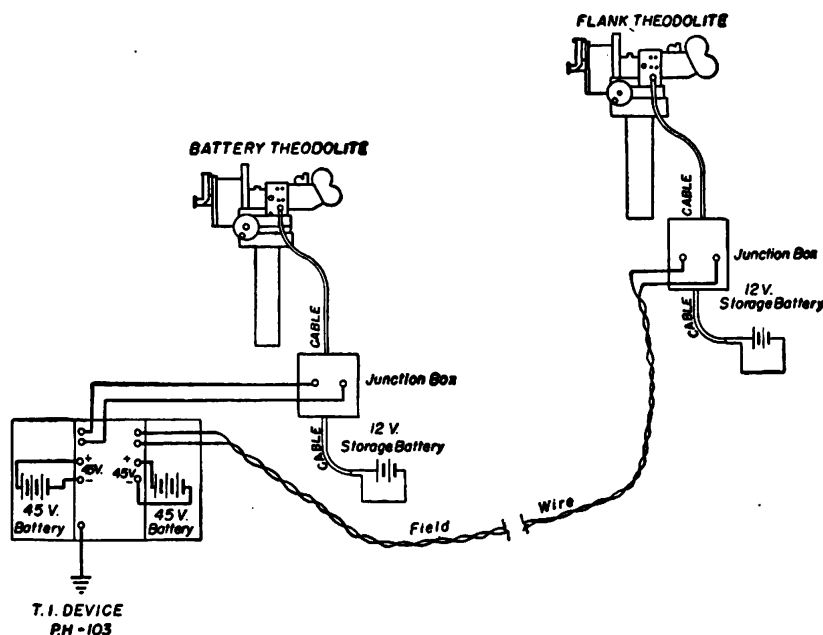


FIGURE 69.—Electrical connections for theodolites PH-BC-33, and time-interval device PH-103.

**81. Time-interval device, type PH-103.**—*Q.* What time-interval device is used with the theodolite PH-BC-33?—*A.* The time-interval device PH-103, known as the electric type, is used.

*Q.* How does the time-interval device, PH-103, operate?—*A.* Two slow-acting relays alternately make and break each other's circuit, and one of these relays makes and breaks a circuit through the time counter line. After the initial adjustment of the period of operation of the relays, the length of time interval is controlled by a rheostat on the time-interval device control panel.

*Q.* How does the time-interval device affect the operation of the time counters?—*A.* A contact on one of the slow-acting relays alternately opens and closes the line from the battery to the binding posts on the panel. The binding posts marked "O<sub>1</sub> junction box" are

connected to a relay in the theodolite which closes the circuit between the time counter and the 12-volt supply battery. The binding posts "O<sub>2</sub> theodolite" are connected to the junction box of the flank camera and operate the time counter in the flank camera in a similar fashion.

*Q.* What is the minimum current which will operate the time counter relay in the theodolite?—*A.* Ten milliamperes.

*Q.* How is the test for ground accomplished?—*A.* The binding post marked "Ground" should be connected through a stake or nail to the ground. Operation of the ground test key, with the starting switch off, to either the O<sub>1</sub> or O<sub>2</sub> position should not cause a reading of the milliammeter. A reading indicates a ground in the appropriate circuit.

*Q.* How is the continuity test accomplished?—*A.* Operation of the continuity test key to either the O<sub>1</sub> or O<sub>2</sub> position should give a reading on the milliammeter. If the reading is full scale, it indicates a short in the line. The reading under normal conditions will depend on the length of wire used in the circuit. Operation of the continuity test key to the O<sub>1</sub> position will operate the counter in the battery theodolite but not the flank theodolite. Similarly, operation to the O<sub>2</sub> position will operate the flank theodolite counter. After making the circuit test, the reading of the time counters should be checked; if they are out of step, they may be put in step by operation of the continuity test key.

*Q.* Are the timing relay circuits and the time counter relay circuit independent?—*A.* Yes. The time relays are operated by one of the two 45-volt batteries and the time counter relay circuits by the other battery. The timing relays may be operated whether the time counter relay circuit is open or closed. If either 45-volt battery fails, the system can be operated on a single battery if the dead battery is disconnected and the battery terminal posts of like polarity on the control panel are connected.

**82. Installation of theodolites.**—*Q.* Who is responsible for installation of the cameras?—*A.* The records section is responsible for installation and operation of the cameras.

*Q.* Who surveys the positions for camera base-end stations?—*A.* Normally, the regimental master gunner, otherwise, the records section.

*Q.* Who installs and maintains the records section communications?—*A.* The records section is responsible for the installation and maintenance of its own lines.

*Q.* How many lines are required for the cameras?—*A.* Three lines: a signal circuit line, a command line, and a spare which is normally used as an intelligence line.

Q. What are some of the requirements for a good camera position? A.—

(1) Accessible by road so cameras do not have to be carried by hand.

(2) Unobstructed field of view of entire field of fire.

(3) Outside the area endangered by gunfire.

(4) Position with respect to field of fire so that it will not be necessary to photograph directly into the sun.

(5) Soil such that pier mount can be rigidly anchored.

Q. What is a satisfactory length for a base line?—A. Stations located from 3,000 to 5,000 yards apart give the best results.

Q. Where should the battery ( $O_1$ ) camera be located?—A. Directly in rear of the firing battery, facing the center of the expected field of fire.

Q. How close to the directing point of the firing battery should the camera post be located?—A. Close enough so that relocation when plotting will be unnecessary, usually 25 to 35 yards.

Q. Which flank should the flank ( $O_2$ ) camera be on?—A. On either the left or right of the firing battery.

Q. Having selected the camera station and emplaced the pier mounts, how are communications installed?—A. Wires are laid along roads or paths to facilitate maintenance; lines may be laid singly or as a cable.

Q. Of what does this cable consist?—A. Six pairs of W-110 are bound together with friction tape at 4- or 5-foot intervals. This temporary cable supplies all the lines needed for the entire records section.

Q. For what are each of the six lines used?—A. The time-interval or signal circuit, the camera command line, the visual time-interval line, the visual command line, an intelligence line, and a spare line.

Q. Why are the camera and visual lines placed in the same cable?—A. The visual section is set up on the same base line, the BC telescopes being set up within 3 yards of the cameras at each end of the base line.

Q. To what are the time-interval wires connected?—A. The time-interval wires are connected to the time-interval terminals on the control box or junction box at each camera.

Q. How and where are the 12-volt storage batteries connected? A.—

(1) *Theodolite PH-BA-33*.—The 12-volt storage battery at each camera is connected to the storage battery terminals of the control boxes.

(2) *Theodolite PH-BC-33*.—The 12-volt storage battery at each camera is connected to the junction box by means of the cord with plug and battery clips.

*Q.* How is the circuit completed from the control or junction box to the camera?—*A.* A cable connects the control box or junction box to the camera through a four-toothed plug and receptacle on the operating panel.

*Q.* Where is the time-interval device placed in the circuit?—*A.* The time-interval device may be placed in the time-interval circuit at any point between the control or junction boxes. Normally the metronome type is placed at the flank station where it will not be affected by the gun firing.

*Q.* How is the time-interval device connected in the circuit? *A.*—

(1) *Time-interval device PH-35*.—The time-interval device is connected in series between the two theodolite control boxes.

(2) *Time-interval device PH-103*.—The time-interval device is connected in series between the two theodolite junction boxes. The binding posts marked "O<sub>1</sub> junction box" on the control panel of the time-interval device are connected to the binding posts on the junction box of the battery camera. The binding posts marked "O<sub>2</sub> theodolite" are connected to the time-interval line going to the flank station. The time-interval line at the flank station is connected to the binding posts on the junction box of the flank camera.

*Q.* Does the power from the 12-volt storage batteries go out over the line?—*A.* No, it goes from the batteries through the control or junction box to the theodolite.

*Q.* How are the battery and flank stations designated?—*A.* The battery station is always O<sub>1</sub> and the flank station O<sub>2</sub>.

*Q.* How many telephones are required in the camera set-up?—*A.* Four telephones are required, two on the command line, two on the intelligence line.

**83. Developing film.**—*Q.* What are the steps in the process of developing? *A.* The steps in developing are placing exposed film on developing reel, developing, rinsing, fixing, washing, and drying.

*Q.* Under what light conditions must these steps be carried out?—*A.* Since panchromatic film is sensitive to all light rays, all steps except washing and drying must be done in total darkness.

*Q.* Why must exposed film be developed?—*A.* When the film is exposed to light in the camera, light rays of varying intensity strike the sensitized negative film. The emulsion on the film contains silver bromide particles, some of which are changed to silver subbromide by the light. The stronger the light ray, the deeper it penetrates the emulsion, changing more silver bromide particles to silver subbromide.

Developing converts the silver subbromide particles into black metallic silver grains to the same extent that light rays have penetrated the emulsion. The developer brings out the exact image projected by the lens in the form of deposits of black metallic silver grains on the film.

*Q.* How is film developed?—*A.* The exposed film, when removed from the magazine, is rewound with the emulsion side toward the center of the roll. This insures that the picture of the target and bursts will be entirely clear of metal contact when wound on the Stineman reel. In winding the film on the Stineman reel, start at the center and guide the film onto the reel with the palm of the hand against the edge of the film. The emulsion side of the film should be upward and not in contact with the reel. The film is fastened to the reel at the inner end by engaging a sprocket hole in the edge of the film over a fixed hook provided on the reel for that purpose. At the outer end, double about one-half inch of the film before inserting in the Stineman reel. The doubled film end provides enough friction to retain the end in place. Grasp the reel at the center and lower it into the developing tank.

*Q.* What are the steps in mixing the developer?—*A.* E. K. developer No. D-11 is furnished in two-part cans. Dissolve the contents of the smaller can in 10 gallons of water. Stir until the contents of this small can are completely dissolved; then add the contents of the large can. Stir until all chemicals are completely dissolved. Film-developer solution deteriorates on exposure to air. Do not allow the developer temperature to rise above 115° F. during the mixing process.

*Q.* What is the proper temperature for the developing, fixing, and washing solutions?—*A.* Developing solution in use should be kept at 60° F. to 65° F. The temperature should not exceed 75° F. in any of the solutions, and all solutions should be approximately the same temperature.

*Q.* How can proper temperature of the processing baths be maintained in hot weather?—*A.* Through the use of an external ice-water bath around the sides and bottom of the processing tanks. Ice may be added to the washing bath as required. Too large a quantity of ice will bring the temperature too low and extend the developing time unreasonably.

*Q.* How many feet of film can be developed per 5 gallons of developer?—*A.* With the E. K. developer No. 11, no more than 1,000 feet of film should be developed in 5 gallons.

Q. What should be done with unused developer solution?—A. Solution should be kept in a completely filled and sealed bottle. Developer solution over 2 days old should never be used.

Q. How should the developing rack be handled while in the developer solution?—A. The reel should be moved up and down rapidly several times when first immersed to prevent air bells. The reel should be rotated several times during developing.

Q. How long should film be developed?—A. The development time will depend upon the developer, the type of film, and the temperature of the developer solution. The time of development as given by the manufacturer should be the time used to develop the film.

Q. What is the next step after the reel is removed from the developer?—A. The reel is immersed and agitated in the washing tank, containing plain water, for about 1 minute. This step washes off excess developer.

Q. Having rinsed the film, what must be done to it?—A. The film must be immersed in the hypo and hardener or fixing solution. The hypo removes the undeveloped silver salts, and the hardener hardens the surface of the film. The film should remain in the hypo solution for approximately 30 minutes when the temperature is 65° F. A general rule is to leave the film in the fixing bath twice the length of time required for the film to clear. The reel should be agitated occasionally while in the fixing bath.

Q. How is the fixing solution mixed?—A. Hypo solution comes in 1-pound cartons. The hardener is in a small package inside the carton. This is dissolved in a pint of lukewarm water which in turn is added to the hypo dissolved in one-half gallon of cold water. The fixing tank is filled to a depth of about 3 inches and brought to a temperature of 65° F.

Q. How long can the hypo be used?—A. When the length of time required for clearing has become twice that for fresh solution, the hypo should be discarded and new hypo used.

Q. After the fixing bath, what is the next step in processing the film?—A. The film is placed for 1 hour in the rinsing tank into which running water is introduced continuously so as to cause a clockwise whirling motion of the bath. A hose led into the tank and laid along the bottom with the mouth of the hose near the side of the tank accomplishes the desired result. Thorough washing of the film is a most important step in proper developing technique.

Q. How is the film dried?—A. Loosen both ends of the film in the reel, place the screen on top, and invert. Immerse screen and reel in the rinsing bath and remove the reel, leaving the film coiled on the rack. Wind the film on the drying rack so that the shiny side

only is in contact with the rack. As it is being wound onto the rack, draw the film through two pairs of viscose sponges; the first set of sponges should be very wet in fresh water, the second pair, damp but squeezed as dry as practicable. This operation with sponges is essential to prevent water spots and to remove foreign material from the film. Unless this work is performed carefully it will be very difficult, if not impossible, to detect small burst images on the film. After it is wound on the rack, loosen both ends of the film occasionally to allow for shrinkage in drying.

*Q.* What is the cause of abrasions or streaks on the developed film and how may they be avoided?—*A.* Marks and abrasions running the length of the film are caused by improper handling. Tightening of a roll of film, without rewinding, should not be attempted. This always causes vertical scratches. Pushing wet film back into the Stineman reel during processing is a common cause for horizontal scratches. Marks on the film may be avoided by exercising care in handling.

*Q.* What causes air bells and how may they be remedied?—*A.* Bubbles of air form on the surface of the emulsion during developing or fixing, preventing proper chemical action of the solution. Remedy by moving the reel frequently during development or fixation in order to break up the air bubbles. Rise in the temperature of the water causes air bubbles to gather on the inside of the tank and reel. To avoid this, draw the water several hours before operations begin.

*Q.* What causes white spots on the finished negative?—*A.* An air bubble formed during development, which prevents developer from acting on the surface beneath the bubble, will show up as a white spot when the film is dried.

*Q.* What causes black spots on the finished negative?—*A.* An air bubble formed during fixation, preventing the acid stop or hypo from ending the action of the developer. Development continues under the bubble, resulting in black spots.

*Q.* What causes blisters on negatives?—*A.* Blisters are caused by a difference of more than 15° F. between the temperatures of any two processing baths. Such temperature differences cause the film emulsion to separate in spots from the film base.

*Q.* What causes brown spots on the finished negative?—*A.* Oxidized developer or fine, undissolved particles of chemical touching the film before development will cause brown spots to form. Excessive rust or impurities in the water may also cause brown spots to appear. Insufficient washing is a common cause of brown spots. Film should be washed at least 1 hour.

**Q.** What causes white crystals to appear on the negative?—**A.** Insufficient washing will leave a coating of hypo which will crystallize out as a white powder on the negative.

**Q.** How should film be handled to avoid fingerprints?—**A.** Handle film by the edges only. Handle dry film with dry hands. After having hands in a solution, wash them in clear water and thoroughly dry before handling any film.

**Q.** What causes lines resembling lightning to appear on the film?—**A.** Static electricity sparks due to friction as the film passes through the camera will leave lines on the negative. Tightening an unexposed roll of film without rewinding also will cause these lines.

**Q.** What type negatives are desirable for antiaircraft artillery analysis?—**A.** Negatives of high contrast are desirable. The blackness or density of the background of the photograph desired, depends upon whether high-explosive shell (black burst) or shrapnel (white burst) are being fired. The desirable density of photographic background also depends upon the color of the target which is being photographed and the type of sky background. The filters and filter factors which have been recommended have been chosen after consideration of the various combinations and, when used in conjunction with proper aperture settings and correct processing technique, should produce negatives of desirable density.

**Q.** How soon after exposure should film be developed?—**A.** In order to prevent a possible loss of density in the film, especially in extremely hot weather, film should be developed within 48 hours after exposure.

**Q.** After being dried, how is the film wound on the reel?—**A.** When the film is completely dry, wind the film on the reel so that the beginning of the film will be on the outside of the reel with the emulsion side toward the center.

**84. Projector equipment, type PH-40.**—**Q.** What means is provided with theodolites PH-BA-33 and PH-BB-33 for viewing the photographs on the film?—**A.** Projector equipment, type PH-40, is furnished with each set of theodolites PH-BA-33 and PH-BB-33.

**Q.** What are the parts of the projector equipment, type PH-40?—**A.** The equipment includes a projector, a metal screen or grid, a combination rewinder and film splicer, and spare reels.

**Q.** What is the diameter of the grid?—**A.** The grid is 100 mils in diameter, divided into squares 10 mils on a side.

**Q.** Why must the grid be rotated during projection?—**A.** The grid must be rotated to the value of the angular height of the target to compensate for the effect of the rotation of the main reflecting prism of the camera.

*Q.* Where is the value of the angular height of the target obtained?—*A.* The angular height appears on the counters photographed on the edge of each frame of the film.

*Q.* How is the film placed in the projector?—*A.* The reel of dried film is placed on the upper spindle so the film comes over the top of the reel and down to the rear. The loose end is placed in the slot of the empty reel on the lower spindle so that it feeds under the reel. The slack film is placed in the groove in rear of the gate, the perforations engaging in the sprocket teeth, and the gate closed. As the

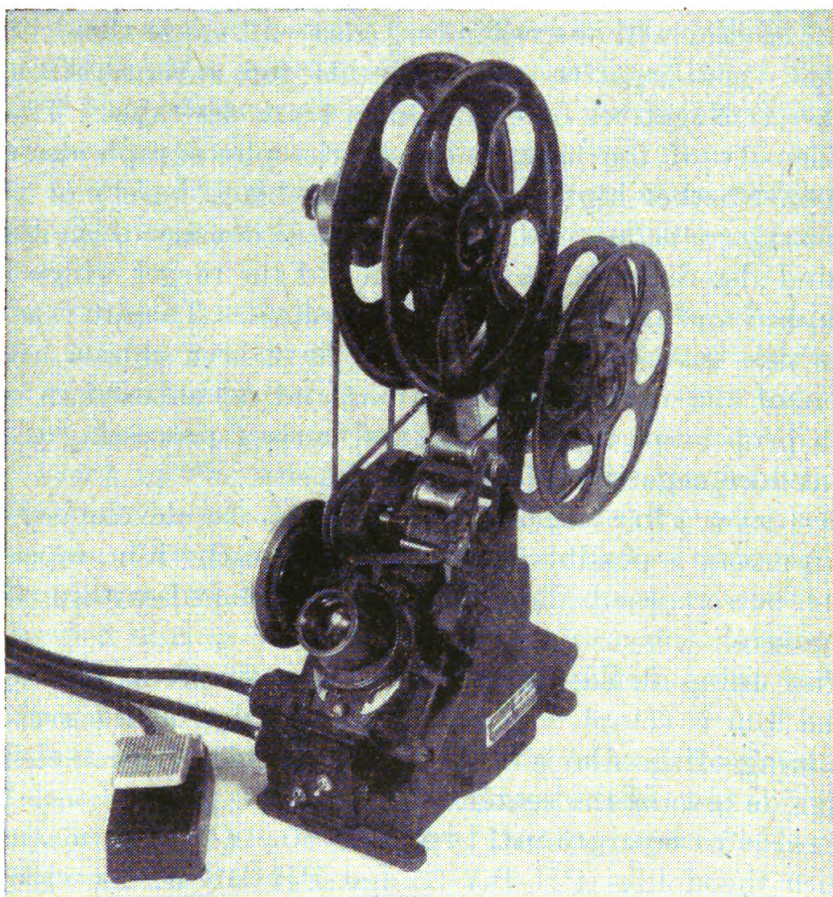


FIGURE 70.—Film viewer, PH-97 (showing commercial viewing glass—viewing attachment PH-98 not shown).

handle is turned, film is pulled from the top reel by the sprockets and taken up on the lower reel by means of a spring-belt drive and pulley. The projector cannot produce a motion picture.

*Q.* Which side of the film should be toward the screen?—*A.* The emulsion or rough side of the film must be toward the screen.

*Q.* Where is the screen set up?—*A.* The screen is set up at the same level as the projector at such a distance that the horizontal indicator shadows are just parallel to the top and bottom edges of the circular grid.

**Q.** How is a sharp image obtained in projecting?—**A.** The lens cylinder is moved back and forth in its collar until a sharp and distinct image appears on the screen.

**85. Film viewer, type PH-97.**—**Q.** What means is provided with theodolites PH-BC-33, for viewing the photographs on the film?—**A.** The film viewer, type PH-97, is furnished with each set of theodolites PH-BC-33.

**Q.** What are the major parts of the film viewer PH-97 and what is the purpose of each?—**A.** An electrically operated editing machine, a viewing attachment PH-98, and spare parts. The film editing machine provides a means of running the film slowly or rapidly while

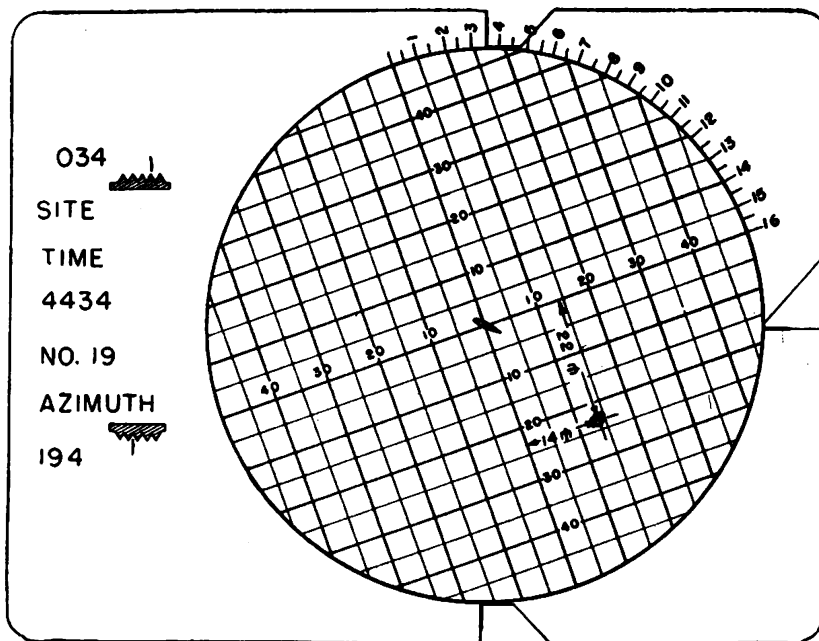


FIGURE 71.—Reticle of eyepiece, film viewer PH-97.

it is viewed through the microscope of the viewing attachment. The speed of the film is controlled by a rheostat and foot pedal. One film drive sprocket is operated by a Geneva movement so that the film may be viewed as a motion picture. A film rewind spindle is provided on the machine. The viewing attachment PH-98 is composed of lenses which form an image of the film in the plane of the reticle, an eyepiece for viewing the image and reticle, and the tube in which this optical system is mounted.

**Q.** What markings appear on the reticle of the viewing attachment PH-98?—**A.** A circular grid divided into squares 5 mils on a side is etched on the reticle. A mil scale, graduated from 0 to 1,600, appears along the circumference of the upper right quadrant. The letters

*R* and *L* also appear beneath the grid to indicate right and left sides of the field which have been reversed by the camera main prism.

*Q.* How is the film placed in the film viewer PH-97? *A.*—

(1) A reel of dry film is placed on either the upper or lower spindle in such a manner that the emulsion side will be down as the film passes through the focal plane of the microscope, and so that the counter data appear upside down on the right side of the film when viewed, without the microscope, from the position of the operator.

(2) The gate is opened, the film guide rollers are retracted from the drive sprockets, and the film is then threaded about the drive sprockets, through the guides, and to an empty reel on the other spindle. Sufficient slack must be left in the film between the two sprockets so that the film is not torn.

(3) The gate is closed, and the rollers are returned to their operating positions.

(4) Before operating the machine by power, the rewind spindle should be turned by hand to see that the amount of slack between sprockets is proper.

(5) The viewing attachment PH-98 is screwed about three turns into the mounting ring of the film gate. When the mounting ring with microscope attached is latched to the film gate in the operating position, the control knob, provided to move the microscope laterally across the film, should be on the operator's left.

*Q.* What adjustments are made when focusing the viewing attachment? *A.*—

(1) The eyepiece clamp should be released, the eyepiece focused on the reticle, and the eyepiece clamp tightened but not forced.

(2) The eyeguard assembly should be adjusted to a comfortable position.

(3) The clamp below the reticle position should be released and the microscope focused by means of the focusing screw. The microscope clamp should then be tightened but not forced.

*Q.* How is the reticle grid aligned with the horizontal and vertical indicators on the film?—*A.* The microscope may be moved in a direction parallel to the film edges by operating a lever mounted at the top of the film gate. Lateral motion across the film is obtained through the operation of a lateral-motion control knob on the left side of the viewing attachment.

*Q.* What data are taken from the film?—*A.* The azimuth and angular height of the target at 5-second intervals.

*Q.* Which film is projected first and why?—*A.* The battery film is usually projected first, since lateral and vertical deviations are ordinarily small, making it easy to pick up bursts on the film.

Q. From which frame is the deviation of the burst read?—A. From the frame on which the burst first occurs.

Q. How is a burst picked out?—A. Film is turned ahead, taking azimuth and angular height each 5 seconds. When a new burst appears clearly on several frames, the film is turned back until the burst appears as a small point. The frame is then centered with reference to the indicators.

Q. How is the deviation read?—A. The grid is rotated to the value of the angular height, and the deviations right or left, above or below, are read to the nearest mil, estimating mils between the smallest graduations.

Q. When the target appears in the film, from what point are deviations read?—A. Deviations are read from the leading point of the sleeve target after it has been centered at the center of the grid.

Q. If the indicator shadows are not tangent to the grid when the target is centered, what corrections must be made?—A. This condition indicates that the target was not at intersection of the cross wires and corrections must be made to azimuth and angular height readings of the target.

Q. If the target is not visible, from what point are deviations measured?—A. Target is assumed to be at the intersection of the cross hairs and the frame is centered so the indicator shadows are tangent to the grid and deviations are read from the center of the grid.

Q. Are the azimuth and angular height of the target recorded for each shot?—A. No, data are taken at 5-second intervals as indicated by the time counters.

Q. How is the time of burst recorded?—A. Time of burst is recorded as counter time plus the number of frames exposed during that second. For instance, a time reading of 3,595+6 on a burst indicates that burst occurred on frame 7 exposed during second 3,595 to 3,596.

Q. Where is the information from the film recorded?—A. All data are recorded on Form AA-18 (Camera Report).

Q. What additional information must be placed on Form AA-18?—A. Form AA-18 includes data for the check point at the beginning and end of the course, rate of counter change, number of times counters failed to turn over, and camera time converted to records time.

Q. How is camera time converted to records time?—A. Operating the metronome at 60 beats per minute and starting the counters at an even hundred at time zero, the last three digits of the time counters give records time in seconds.

**Q.** How are bursts picked up on the flank film?—**A.** Using the time of burst as determined from the battery film, the flank film is turned ahead until the corresponding frame number appears. The burst will appear on the flank film within one or two frames of the frame number on which it appeared on the battery film. Slight difference in frame numbers occur due to the fact that the film is not fed through at exactly the same speed in both cameras.

## SECTION VIII

## OPERATION OF METEOROLOGICAL SECTION

|  | Paragraph |
|--|-----------|
| Meteorological message.....                            | 86        |
| Description and use of meteorological instruments..... | 87        |
| Plotting.....  | 88        |
| Use of tables.....                                     | 89        |

**86. Meteorological message.**—**Q.** What is the necessity for the meteorological message?—**A.** The meteorological message is used to supply the artilleryman with accurate information of three meteorological elements: air temperature, air density, and wind direction and velocity.

**Q.** Why is an artilleryman interested in these three elements?—**A.** Because the behavior of a projectile after it is fired is influenced by any differences in these elements from those assumed as standard in the construction of firing tables.

**Q.** What are the standard conditions assumed in the construction of firing tables? **A.**—

|                          |                              |
|--------------------------|------------------------------|
| Air temperature.....     | 59° F.                       |
| Barometric pressure..... | 29.528 inches of mercury.    |
| Relative humidity.....   | 78 percent.                  |
| Air density.....         | 525.9 grains per cubic foot. |
| Wind.....                | None.                        |

**Q.** Why is it necessary to take readings other than at the surface?—**A.** Artillery shells are influenced by the atmospheric conditions throughout the entire trajectory. The conditions of temperature, density, and wind vary at different altitudes.

**Q.** Of the three elements which one is accurately charted for all altitudes?—**A.** Wind is the one element which is accurately charted for all altitudes.

**Q.** How are the other two elements determined?—**A.** By observing the surface conditions and assuming a uniform decrease in value for each definite increase in altitude above the observation station.

*Q.* Why is it necessary for the message to be accurate?—*A.* With the speed of modern airplanes, accurate preparation of fire, which is dependent on the meteorological message, is of primary importance.

*Q.* What are the main steps in the preparation of the meteorological message? *A.*—

(1) Determine the true wind for each altitude zone.

(2) Determine the true wind for each of the standard maximum ordinates.

(3) Make the surface observations.

(4) Determine the ballistic air densities.

(5) Encode the artillery meteorological message.

*Q.* How many men are necessary in the preparation of the meteorological message?—*A.* Four men: plotter, assistant plotter, observer, and reader.

*Q.* How often should a meteorological message be prepared?—*A.* A meteorological message should be in preparation at all times; a new one is started as soon as one is completed.

*Q.* In actual field set-up, how would the message be relayed to the firing units?—*A.* By telephone to be of the most value, and by messenger if there are no wire communications.

*Q.* Of how many messages does the complete message consist?—*A.* A complete meteorological message consists of two messages, one for high-angle fire and one for low-angle fire.

*Q.* How is the message for high-angle fire identified?—*A.* The first group of digits is preceded by the figure 2.

*Q.* Of what does each message consist?—*A.* Each message consists of a group of three letters repeated once, followed by one group containing five digits, followed by several groups of figures, each containing seven digits.

*Q.* What is the meaning of the two groups of three letters?—*A.* The two groups of three letters are the station identification letters in code.

*Q.* What is the meaning of the five-figure group?—*A.* The first digit indicates the type artillery for which the message is intended, such as 2 for high-angle fire. The second and third digits indicate in hundreds of feet the height of the observation station above the mean datum plane. The fourth and fifth digits indicate in degrees Fahrenheit the temperature at the observation station.

*Q.* What do the seven-figure groups indicate?—*A.* The first digit indicates the maximum ordinate of the zone. The second and third digits indicate in hundreds of mils from north the direction from which the ballistic wind is blowing. The fourth and fifth digits indicate in miles per hour the velocity of the ballistic wind. The sixth

and seventh digits indicate the ballistic air density in percent of the artillery standard.

*Q.* What are the maximum ordinates corresponding to the first digits in the groups of seven figures? *A.*—

|                       |                 |
|-----------------------|-----------------|
| 0—Surface conditions. | 6—9,000 feet.   |
| 1—600 feet.           | 7—12,000 feet.  |
| 2—1,500 feet.         | 8—15,000 feet.  |
| 3—3,000 feet.         | 9—18,000 feet.  |
| 4—4,500 feet.         | 10—24,000 feet. |
| 5—6,000 feet.         | 11—30,000 feet. |

*Q.* What is the eighth zone?—*A.* The eighth zone is the altitude between 12,000 and 15,000 feet designated by the digit 8.

*Q.* Why is it important that the message have the starting time placed on it?—*A.* Conditions often change quite rapidly; time started being shown obviates the use of an old message.

*Q.* When should the message be distributed?—*A.* A message should be distributed as soon as completed and encoded.

#### **87. Description and use of meteorological instruments.—*a.***

*General.*—*Q.* What equipment is required in a field meteorological station for day observations?—*A.* A theodolite, a stopwatch or watch with second hand, an anemometer, a barometer (with correction tables), a psychrometer, a thermometer, sounding balloons, hydrogen gas, hose, coupling and filling cock, plotting boards types ML-55 and ML-57, scales types ML-87 and ML-88, copies of W. D., S. C. Form No. 206 (Meteorological Data Sheet for Artillery), a copy of TM 4-240, and tables of vertical and horizontal components of distances of pilot balloons.

*Q.* What additional equipment is necessary for night observation?—*A.* The theodolite must be equipped with lights for night observations. One-inch candles, paper lanterns, and a very fine wire or string are also needed.

*Q.* Why is it necessary to have a stop watch or other accurate timing device?—*A.* In order that readings may be taken on the balloon at the prescribed intervals.

*Q.* Where is the information obtained from the various instruments recorded?—*A.* On Signal Corps Form No. 206, the meteorological data sheet for artillery.

*b. Theodolite.*—*Q.* What is a theodolite?—*A.* A theodolite is an instrument similar to a transit by which an observer may track moving objects such as balloons and read their elevation and azimuth at any instant.

*Q.* How does a theodolite differ from a transit? *A.* The telescope of a theodolite is fitted with a right-angled prism which inverts the image to an observer whereas a transit uses direct sight and the image is not inverted.

*Q.* Of what does the theodolite consist?—*A.* The theodolite consists of a right-angled prismatic telescope and two circular limbs, one horizontal and one vertical, divided into degrees and equipped with verniers.

*Q.* Point out the following parts of the theodolite:

|                  |                 |
|------------------|-----------------|
| Vertical limb.   | Focusing knobs. |
| Azimuth vernier. | Handrail.       |
| Leveling screws. | Rear sight.     |
| Spirit levels.   | Counterbalance. |
| Eyepiece.        | Bedplate clamp. |
| Sunshade.        | Plumb bob.      |
| Cross hairs.     |                 |

*Q.* What is the least reading on the vernier?—*A.* One-tenth of 1°.

*Q.* How is the telescope moved in azimuth and elevation?—*A.* By means of tangent screws.

*Q.* How may the theodolite be traversed or elevated in fast motion?—*A.* By "throwing out" the tangent screws and moving by hand.

*Q.* What is the purpose of the knurled head for the stem on the tripod?—*A.* To hold the theodolite firmly in place on tripod, by tension against the tension spring.

*Q.* How should a theodolite be kept when not actually in use?—*A.* A theodolite when not actually in use should be placed in carrying case or box provided for that purpose and stored in a dry place.

*Q.* How should the lens and eyepiece be cleaned?—*A.* By the use of a soft brush only, never by rubbing with fingers or cloth.

*Q.* What type oil should be used on moving parts of a theodolite?—*A.* A good grade of clock oil.

*Q.* Name the steps in setting up a theodolite. *A.*—

(1) Set the tripod on the ground with the plate approximately horizontal.

(2) Clamp the legs.

(3) Grasp the theodolite by the handrail and base, place it on the plate, and take up the tension spring by means of the knurled head on the stem.

(4) Move the head until the plumb bob is directly over the point of the station.

- (5) Point the telescope toward the sky and focus the cross hairs.
- (6) Sight on some object at least 100 feet away and focus the telescope by means of the focusing adjusting screw.
- (7) Orient approximately.
- (8) Level.
- (9) Recheck the orientation on the original and alternate points, preferably points over 500 yards away.

*Q.* Describe the orientation of the theodolite, knowing the azimuth to one or more points. *A.*—

- (1) Set up and level the instrument.
- (2) By means of the azimuth tangent screw, set the known azimuth on the azimuth circle vernier.
- (3) Loosen the bedplate clamp and bring the telescope approximately on the known datum point.
- (4) Clamp the bedplate and bring the cross hairs on the center line of the datum point by means of the bedplate slow-motion screw.
- (5) Check the orientation on another known point, preferably one several thousand yards away.

*Q.* Why is it necessary to level the theodolite?—*A.* To make certain that all angles will be measured in true horizontal and vertical planes.

*Q.* To what altitude should the balloon be observed?—*A.* To the upper limit of the zone next above the maximum altitude required by the batteries.

*Q.* At what intervals are readings taken on the balloon?—*A.* At 1-minute intervals, starting at zero.

*Q.* How is time zero determined?—*A.* Time zero is the instant the chief of section commands LET GO, releases the balloon, and starts the stop watch.

*c. Balloons.*—*Q.* In what colors are pilot balloons furnished?—*A.* In red, natural, and black.

*Q.* When should the various colored balloons be used?—*A.* The red balloon should be used on partly cloudy or hazy days; the black balloon should be used on cloudy days; and the natural-colored balloon should be used on clear days.

*Q.* How should the balloon be inflated? *A.*—

- (1) Knead the balloon between the palms of the hands to make it pliable.
- (2) Attach the hose coupling to a cylinder of hydrogen and the hose cock on the other end of the hose.
- (3) With the cock open, turn on the hydrogen so as to expel the air from the hose.
- (4) Roll the balloon so as to expel all air and insert the end of the hose cock in the balloon.

(5) Inflate slowly to about 25 inches in diameter.

(6) Test the balloon until it just supports the hose cock.

*Q.* What precautions should be taken when inflating a balloon? Why? *A.*—

(1) Do not inflate the balloon too rapidly or it will burst due to uneven tension.

(2) Do not inflate the balloon near an open flame or a lighted cigarette as hydrogen is highly explosive.

*Q.* Why must the balloon just balance the hose cock when fully inflated?—*A.* A hose cock weighs exactly 132 grams. It has been found that when a balloon weighing 30 grams is so inflated with hydrogen as just to balance a weight of 132 grams in equilibrium, the balloon will ascend at a satisfactory rate when the weight is removed.

*Q.* What is the average rate of ascent with the balloon properly inflated? *A.* During—

|                             | <i>Yards</i> |
|-----------------------------|--------------|
| First minute.....           | 240          |
| Second minute.....          | 220          |
| Third minute.....           | 220          |
| Fourth minute.....          | 210          |
| Fifth minute.....           | 210          |
| Each subsequent minute..... | 200          |

*d. Psychrometer.*—*Q.* What is a whirling psychrometer?—*A.* An instrument consisting of one wet-bulb and one dry-bulb thermometer so mounted on the same base that they may be whirled in the air simultaneously.

*Q.* What is the difference between a wet bulb and a dry bulb?—*A.* The wet bulb is covered with a single thickness of thick wicking which is immersed in water just before the psychrometer is whirled while no covering is provided for the dry bulb.

*Q.* How is the psychrometer used?—*A.* Wet the wick on the wet bulb and whirl the psychrometer, stopping after 10 seconds to read both thermometers. Continue this procedure until the mercury in the wet-bulb thermometer does not go down any lower. Read and record the lowest temperature indicated by this thermometer and simultaneously the temperature indicated by the dry-bulb thermometer.

*Q.* What is the purpose of the two separate readings?—*A.* The difference in the readings of the two thermometers is used to enter tables for the purpose of determining the relative humidity of the atmosphere.

*e. Aneroid barometer.*—*Q.* What is an aneroid barometer?—*A.* An instrument for measuring the pressure of free air.

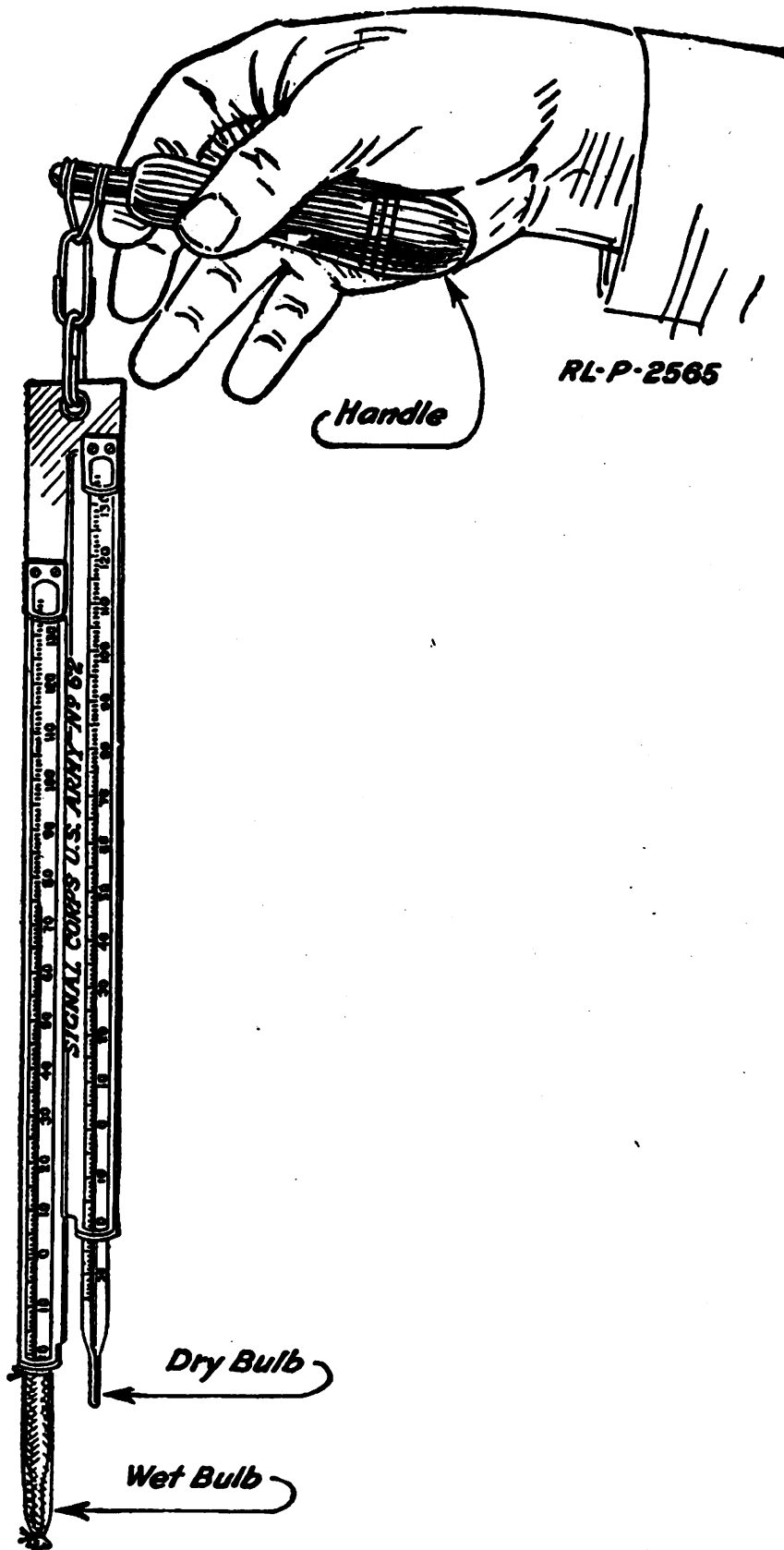
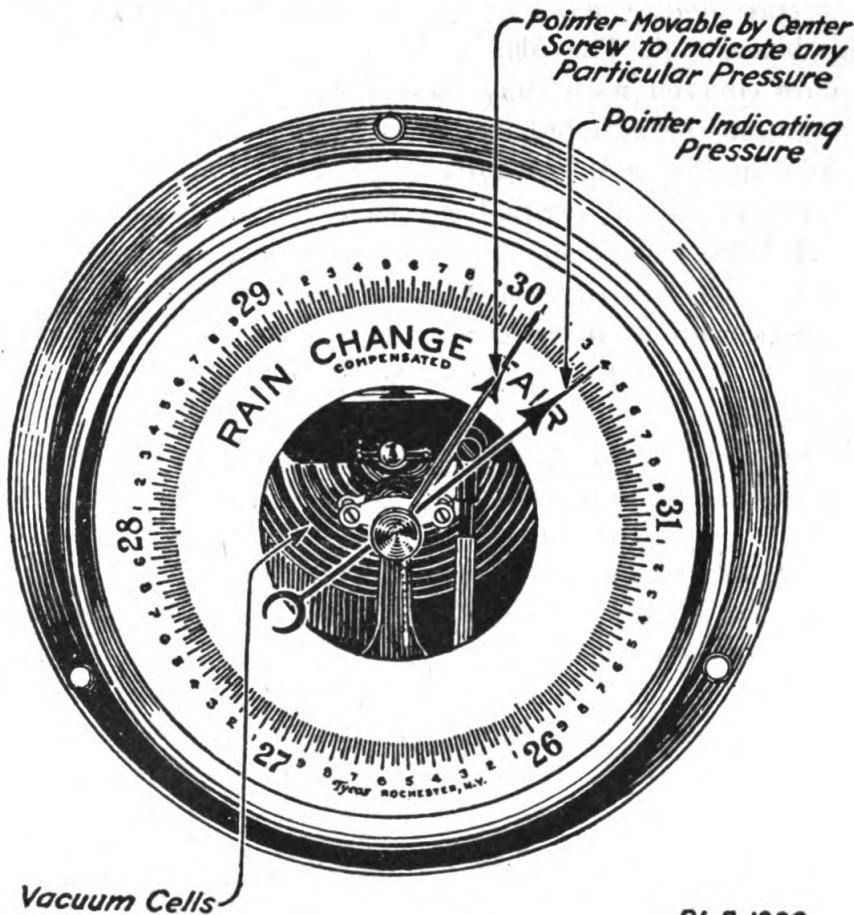


FIGURE 72. Psychrometer (whirled).

*Q.* How is the aneroid barometer read?—*A.* To read the aneroid barometer, place the barometer flat in a shaded place, tap gently with the fingers, and read the air pressure.

*f. Thermometer.*—*Q.* How should the thermometer be exposed to obtain accurate readings?—*A.* It should be whirled in a shaded spot away from buildings, or else exposed in a special shelter made for this particular purpose.



RL-P-1389

FIGURE 73.—Aneroid barometer.

*Q.* How should a thermometer be read?—*A.* A thermometer should be read with the eyes at the same height as the mercury column so as to avoid parallax and a resulting false reading.

*Q.* What is the smallest reading required when reading a thermometer?—*A.* One-tenth of  $1^{\circ}$ .

*g. Anemometer.*—*Q.* What is an anemometer?—*A.* An anemometer is a device for measuring the surface velocity of the wind in miles per hour and the direction from which the wind is blowing.

*Q.* Is it necessary to reduce readings from an aneroid barometer to standard conditions?—*A.* No. The readings are sufficiently accurate for artillery use.

**88. Plotting.**—*a. General.*—*Q. What is a ballistic wind?*—*A.* A ballistic wind is a fictitious wind, constant in velocity and direction, which would have the same total effect on the projectile during its flight as the true value actually encountered. It is a computed value.

*Q. What type plotting boards are required to plot the meteorological message?*—*A.* Two plotting boards are necessary to plot the meteorological message, one ML-55 and one ML-57.

*b. Plotting board ML-55.*—*Q. Describe briefly the type ML-55 plotting board.*—*A.* The ML-55 board is a drawing board about 4 feet square covered with linen-back paper on which is drawn a circular protractor graduated in degrees clockwise from the top of the board and in hundreds of mils clockwise from the bottom of the board, and on which is ruled a system of north-south lines 1 inch apart. A brass rule, type ML-63, is pivoted at the center of the protractor. The third, or lower left-hand quadrant, is ruled into 1-inch grids, and the protractor in this quadrant is graduated counterclockwise from zero to 90° in addition to the normal clockwise graduations.

*Q. What is the grid in the lower left-hand corner used for?*—*A.* To determine the horizontal distance of the balloon from the theodolite. Using the observed angular height of the balloon and the altitude of the balloon computed from the known rate of ascent, the horizontal distance of the balloon from the observer may be determined by using the brass scale ML-63.

*Q. Is this the usual way of obtaining horizontal distances?*—*A.* No. The usual method is by use of tables.

*Q. What is the scale of the brass scale pivoted at the center?*—*A.* One inch equals 500 yards.

*Q. What is the first step in plotting the horizontal projection of the path of the balloon?*—*A.* To determine the direction and horizontal distance of the balloon from the observation station at any instant.

*Q. How are the points representing the position of the balloon at any instant plotted?* *A.*—

(1) Set the edge of the brass scale at the azimuth read from the theodolite.

(2) Find on the edge of the brass scale the horizontal distance of the balloon from the station.

(3) Mark this point with a "T" and under it the number of minutes after time zero that the reading was taken.

*Q. What does the point at which the brass scale is pivoted represent?*—*A.* The position of the theodolite.

*Q.* What points should be plotted on board type ML-55?—*A.* Points should be plotted representing the position of the balloon 1,  $2\frac{1}{4}$ ,  $4\frac{1}{2}$ , 7,  $9\frac{1}{2}$ ,  $14\frac{1}{2}$ ,  $19\frac{1}{2}$ ,  $24\frac{1}{2}$ ,  $29\frac{1}{2}$ ,  $39\frac{1}{2}$ , and  $49\frac{1}{2}$  minutes after time zero.

*Q.* Why are these points used?—*A.* Because they represent the points of division between different altitude zones.

*Q.* Are these points determined by taking readings at these times?—*A.* No. They are obtained by interpolating between readings taken at 1-minute intervals.

*Q.* The direction of the wind as plotted always refers to what?—*A.* To the direction from which the wind is blowing.

*Q.* Why is the direction of a wind from north expressed as 6,400 mils rather than zero?—*A.* Because zero is reserved for use when there is no wind blowing.

*c. Scale, type ML-87.—Q.* What scale is used to determine the direction and velocity of the wind in any zone?—*A.* Scale, type ML-87.

*Q.* When determining wind directions from the plot, where should the center of the protractor on scale ML-87 be placed?—*A.* Directly over the point representing the position of the balloon at the lower boundary of the altitude zone.

*Q.* How is the protractor oriented?—*A.* The protractor is oriented with the parallel lines running in a north-south direction.

*Q.* How is the azimuth of the wind read?—*A.* The azimuth of the wind is read from the end of the radial line of the protractor that most nearly passes over the point representing the position of the balloon at the top of the altitude zone.

*Q.* When the circle of the protractor is on the right, which azimuth figures are used?—*A.* The inside figures, or azimuths from 3,200 to 6,400 mils are used.

*Q.* How may an error of 3,200 mils in determination of wind direction be avoided?—*A.* The protractor must always be oriented 3,200 mils from the true direction when used on plotting board, type ML-55.

*Q.* What is another method of avoiding errors in true wind direction?—*A.* By remembering that wind direction is always measured from an earlier to a later plotted point.

*Q.* How is wind speed in a zone determined?—*A.* By using the proper scale along the edge of the ML-87 scale.

*Q.* If the interval between two points represents 5 minutes, what scale should be used?—*A.* The  $2\frac{1}{2}$ -minute scale should be used and the results divided by two.

*Q.* If the winds are strong and the plot goes off the board, what steps should be taken?—*A.* Plot as far as possible using a scale 1

inch equals 500 yards; then plot the remaining points to a scale of 1 inch equals 1,000 yards.

*Q.* If this change in scale becomes necessary, what precaution must be taken?—*A.* That all points in any one altitude zone are plotted to the same scale.

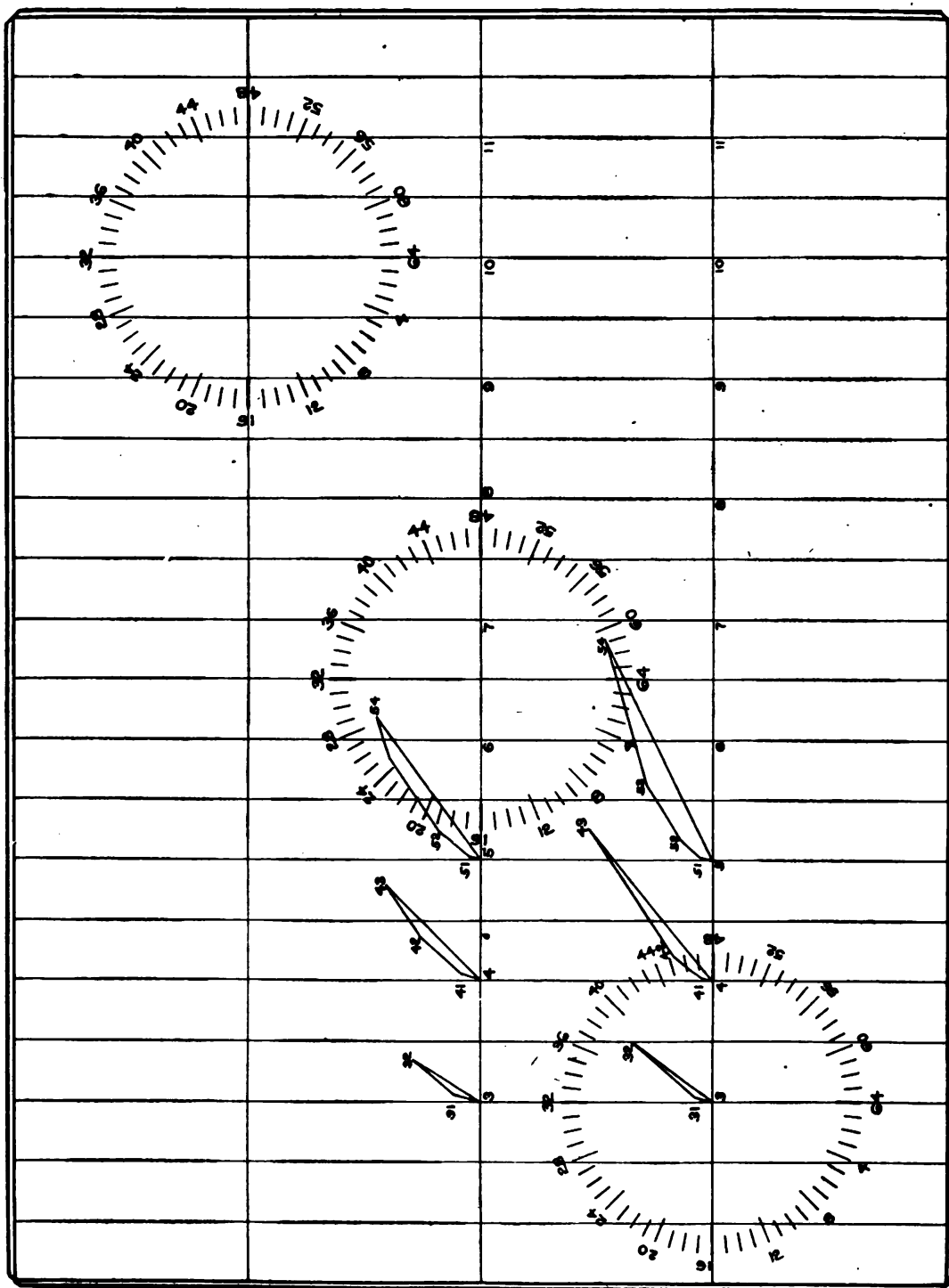


Figure 74.—Plotting board, type ML-57.

*Q.* Since the wind speed scale is constructed for use with a scale of 1 inch equals 500 yards, what steps are necessary in obtaining wind speeds when the scale is doubled?—*A.* The wind speed as read must be doubled.

*Q.* If the balloon is lost to view before it reaches the required height, how may data be obtained?—*A.* If the balloon is observed while passing through approximately half a zone, its position at the top of the zone may be estimated.

*d. Plotting board ML-57 and scale ML-88.—Q.* What other type plotting board is required in completion of the meteorological message?—*A.* Plotting board, type ML-57.

*Q.* What is the purpose of the ML-57 board?—*A.* The ML-57 board is used to plot and compute weighted wind values.

*Q.* How many horizontal lines are there on the board and for what are they used?—*A.* There are three horizontal lines on the ML-57 board. The upper one is for plotting aerial bomb data, the center one for plotting high-angle artillery data, and the bottom one for plotting low-angle artillery data.

*Q.* Is it necessary to complete all the operations on the ML-55 board before starting the plot on the ML-57 board?—*A.* No. The two plots are carried on simultaneously.

*Q.* What do the figures 3, 4, 5, etc., at the intersections of the horizontal and vertical lines represent?—*A.* Each point represents the origin of a wind polygon for one of the various altitude zones.

*Q.* Why is it necessary to use weighted wind speeds in plotting wind polygons on the ML-57 board?—*A.* Because the projectile spends a greater length of time in some zones than in others and the wind effect in different zones will vary.

*Q.* How is a weighted wind value obtained?—*A.* By multiplying the true wind speed in the various altitude zones by appropriate figures known as weighting factors.

*Q.* Who does the plotting on the type ML-57 plotting board?—*A.* The assistant plotter.

*Q.* Is it necessary to plot zone winds to determine the ballistic winds for maximum altitudes 600 feet and 1,500 feet? Why?—*A.* It is not necessary to plot zone winds in these altitudes, since the true average wind during the first minute of ascension of the balloon is used for the 600-foot ordinate and the true average wind for the first  $2\frac{1}{4}$  minutes of ascension for the 1,500-foot ordinate.

*Q.* When the plotter has determined the average true wind speed and direction for the first  $2\frac{1}{4}$  minutes of ascent of the balloon, what is plotted on the ML-57 board?—*A.* Using protractor, type ML-88,

the true direction of the wind is plotted from each point starting at point 3 on the center horizontal line 6 inches from the left edge of the board.

Q. How is protractor, type ML-88, oriented?—A. The parallel lines are always in a north-south direction. If the direction of the wind as recorded on W. D., S. C. Form No. 206 is on the inner circle

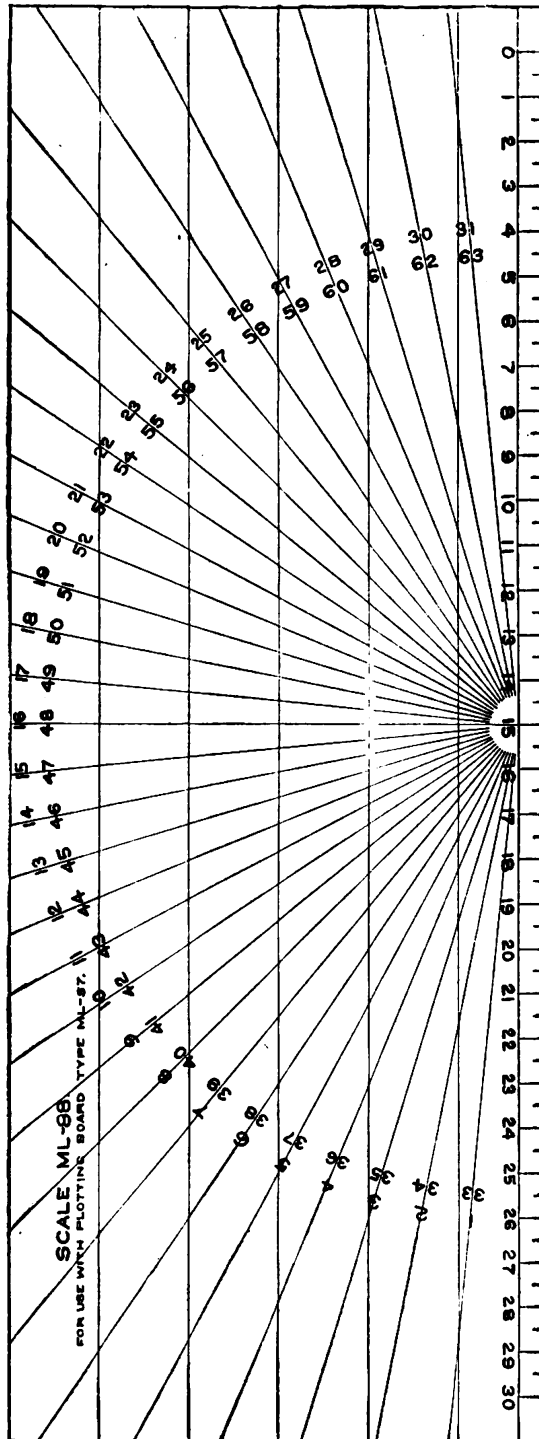


FIGURE 75.—Scale, type ML-88.

of figures, the circle of the protractor should be to the right. A safe rule always is to orient the circle 3,200 mils from the true direction.

*Q.* How is the length of the line or wind speed determined?—*A.* The length of the line or wind speed is determined from tables of weighted wind values by the assistant plotter who determines the length of the line to be laid off from each point, 3, 4, 5, etc.

*Q.* How are these points labeled?—*A.* These points are marked 31, 41, 51, etc.

*Q.* When the true wind speed and direction for the altitude zone from 1,500 to 3,000 feet has been determined by the plotter, what is the next step for the assistant plotter?—*A.* The next step for the assistant plotter is to determine the position of, and plot, by means of proper tables, points 42, 52, 62, etc.

*Q.* How far does this process continue?—*A.* This process continues until the weighted wind value to the upper limit of all altitude zones up to 30,000 feet has been plotted, or until the balloon is lost.

*Q.* Having plotted all ballistic points, how is the ballistic wind determined?—*A.* The ballistic wind is determined by closing the wind polygon, that is, drawing a line from the last plotted point in each series to the origin. (Example: From point 32 to 3, 43 to 4, etc.) The azimuth of this line and the length as measured by protractor and scale ML-88 is the direction and speed of the ballistic wind for that altitude zone.

*Q.* Where are the direction and speed of the ballistic wind recorded?—*A.* The direction and speed of the ballistic wind are recorded under heading "Ballistic data" on W. D., S. C. Form No. 206.

*Q.* What is the purpose of the graduated circles on the ML-57 board?—*A.* Those graduated circles are used when plotting with parallel rulers instead of the type ML-88 scale and protractor.

**89. Use of tables.—a. General.**—*Q.* What is the purpose of tables?—*A.* To eliminate the necessity for calculations by presenting data in a convenient form, thus saving time and reducing errors.

*Q.* How can tables be used if the values with which they are entered are not shown exactly in the tables?—*A.* By interpolation.

*Q.* What is meant by interpolation?—*A.* Interpolation is the determination of the value intermediary between two or more given values. It is a continuation of the values listed in tables.

*Q.* Why is interpolation often necessary in preparation of the meteorological messages?—*A.* The tables are composed of values for certain conditions, whereas the conditions actually observed may

differ from the listed arguments, thereby requiring interpolation to obtain true values.

*b. Table VI, TM 4-240.—Q.* What values are used to enter this table?—*A.* The temperature of the air as read from the dry bulb of the thermometer and the difference between the wet and dry bulbs when the whirling psychrometer is read.

*Q.* If the air temperature is 58° F. and the wet bulb reads 47° F., what is the relative humidity?—*A.* The relative humidity is 41 percent of normal.

*Q.* If the air temperature is 30° and the wet-bulb depression is 6.3°, what is the relative humidity?—*A.* The relative humidity is 34 percent of normal.

*c. Tables VII and VIII, TM 4-240.—Q.* What values are used to enter table VII?—*A.* The atmospheric pressure as read from the barometer and the air temperature in ° F. as read from the dry bulb of the whirling psychrometer.

*Q.* If the relative humidity is other than 78 percent, what correction is made to the value obtained from table VII?—*A.* The correction is determined from table VIII, using relative humidity and temperature as arguments.

*Q.* Is it necessary to reduce barometric pressure to sea level before using it as an argument to enter tables VII or VIII?—*A.* It is not necessary to reduce barometric pressure to sea level as the values listed in the tables are without reference to sea level pressure.

*d. Table X, TM 4-240.—Q.* What altitude is used to enter this table?—*A.* The altitude of the observation station to the nearest 100 feet.

*Q.* If the altitude of the station is between 0 and 1,000 feet, is it necessary to interpolate?—*A.* Yes, it is necessary to interpolate for values between 0 and 1,000 feet, as only values for 0, 1,000, and 2,000 feet are given.

*Q.* What other value besides altitude is used to enter table X?—*A.* The value of the atmospheric density at the meteorological station is also used.

*Q.* Knowing the entering values, what values are obtained and where are they recorded?—*A.* The weighted ballistic density for each maximum ordinate is determined and recorded under "Ballistic data" on W. D., S. C. Form No. 206.

*Q.* If the station altitude is 500 feet and the surface density is 100 percent, what is the ballistic density for maximum ordinate of 18,000 feet?—*A.* The ballistic density for maximum ordinate of 18,000 feet will be 100.1 percent.

*Q.* Are the values obtained from table X corrected for other conditions?—*A.* The values obtained from table X are not corrected for other conditions. The values as read from the tables are the desired ballistic densities for use in completing the meteorological message.

*e. Tables I and II, TM 4-240.*—*Q.* What are the values shown in table I?—*A.* The wind weighting factors by which the true wind values in the various zones are multiplied to find the weighted wind values listed in table II.

*Q.* What value is used to enter table II?—*A.* The true wind speed for the zone listed at the top of the page, as determined from the plot on board, type ML-55.

*Q.* Why is there no value for points 33, 44, 55, etc., in the tables?—*A.* These values are not needed since they are values for points above the maximum ordinate desired and are not needed in plotting to obtain the ballistic wind for that particular maximum ordinate.

*Q.* For the zone 3,000-4,500 feet with a wind speed of 31 miles per hour, what is the weighted value of the wind for point 63?—*A.* In this zone with a wind speed of 31 miles per hour, the weighted value of the wind for point 63 is 6.2 miles per hour.

*f. Tables of vertical and horizontal components of distances of pilot balloons.*—*Q.* Of what use are the tables of vertical and horizontal components of distances of pilot balloons?—*A.* These tables are a simple, accurate, and rapid means of determining horizontal distances of balloons, when the time of observation and angular height as read from the theodolite are known.

*Q.* If the angular height of the balloon is  $30.6^\circ$ , what is the horizontal distance to the balloon 11 minutes after its release?—*A.* The horizontal distance to the balloon 11 minutes after release, when the angular height is  $30.6^\circ$ , is 3,890 yards.

*Q.* Since the tables have been computed for only 30 minutes, how can values be obtained for readings up to 50 minutes?—*A.* Multiply the altitude of the balloon as shown in column 2, Form No. 206, by the value of the natural cotangent of the observed angle from column 3, Form No. 206 to get the horizontal distance to the balloon.

*Q.* Where may these values be found?—*A.* These values may be found in the back of Circular 8-14, tables of vertical and horizontal components of distances of pilot balloons.

## CHAPTER 5

## ANTIAIRCRAFT GUN FIRING SECTION

|  | Paragraphs |
|--|------------|
| SECTION I. Gun and mount.....                | 90-94      |
| II. Duties of members of firing section..... | 95         |
| III. Ammunition—basic.....                   | 96-97      |
| IV. Preparation for service practice.....    | 98-100     |
| V. Pointing and firing.....                  | 101-103    |

## SECTION I

## GUN AND MOUNT

|  | Paragraph |
|--|-----------|
| 3-inch antiaircraft gun M3.....            | 90        |
| 3-inch antiaircraft gun M1917 (fixed)..... | 91        |
| 105-mm antiaircraft gun M3.....            | 92        |
| Inspection and maintenance.....            | 93        |
| Fuze setters.....                          | 94        |

**90. 3-inch antiaircraft gun M3.—Q.** Does the breech of this gun open on recoil or counterrecoil? **Explain.—A.** It opens on counterrecoil. The operating-cam cover is mounted on the cradle and does not move with the gun in recoil. The operating cam is mounted on the hub in the cover, which permits it to rotate. A spring keeps the cam in the forward position. As the gun recoils, with the operating crank in the vertical position, the gun strikes the operating cam and rotates it backward, the spring pulling the cam forward again as soon as the gun clears it. When the gun goes into counterrecoil, the operating crank strikes the cam and is rotated until it brings the breechblock down to its open position, when the crank passes under the cam and completes its counterrecoil, leaving the block open.

**Q.** How is the breech set for normal operation?—**A.** The clutch on the operating handle is disengaged by turning the knob all the way out (counterclockwise) with breech open, handle in upright position and latched, and with operating cam in upper notch.

**Q.** How is the breech set for semiautomatic action?—**A.** The clutch on the operating handle is disengaged by turning the knurled knob counterclockwise as far as it will go, about four turns. The breech is then opened, if closed, and the handle returned to its upright position and latched. The operating cam on the mount, just to the left of the breech, is then placed in position in its lower notch, out of the way of the crankpin on the operating shaft.

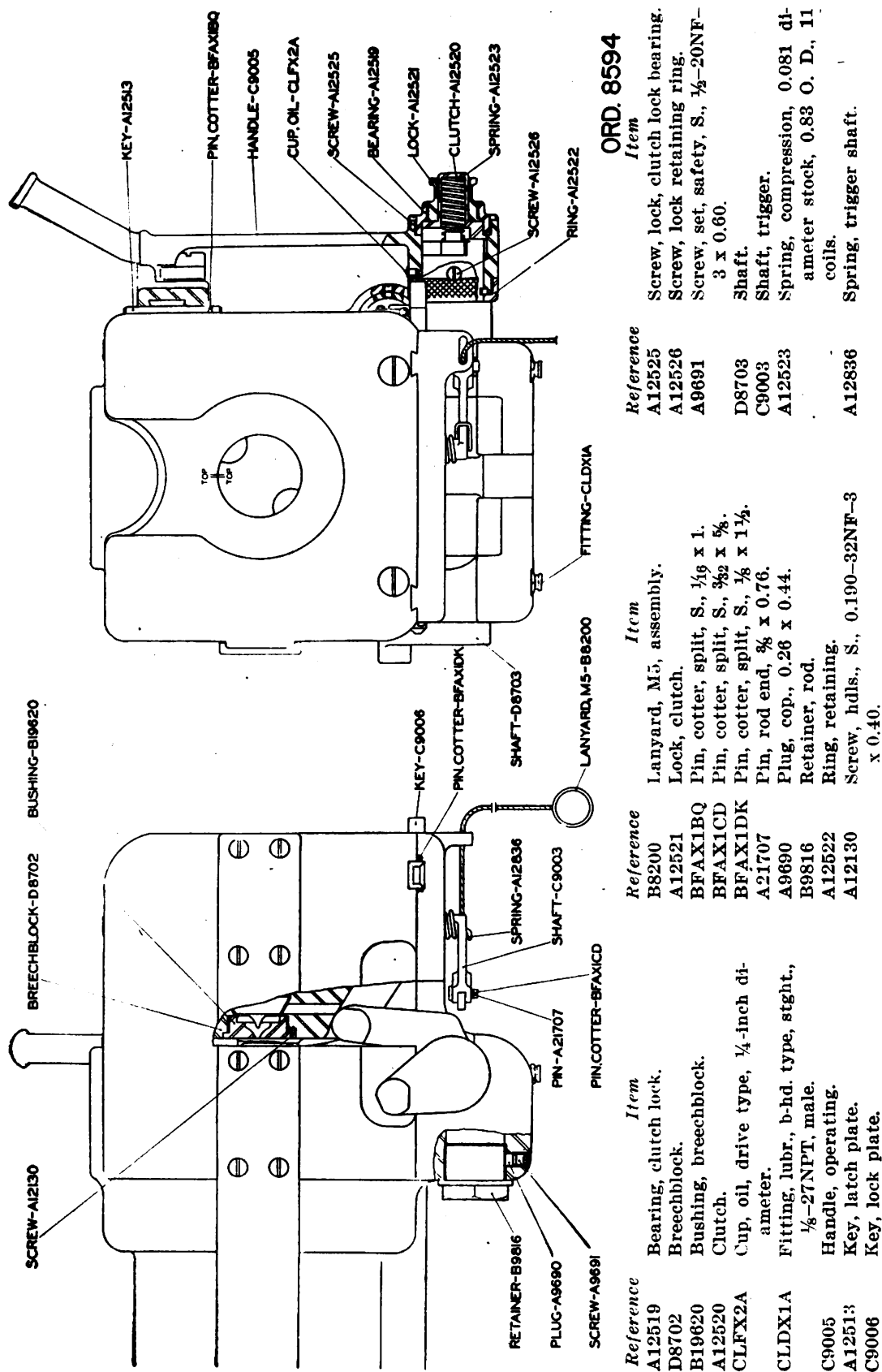
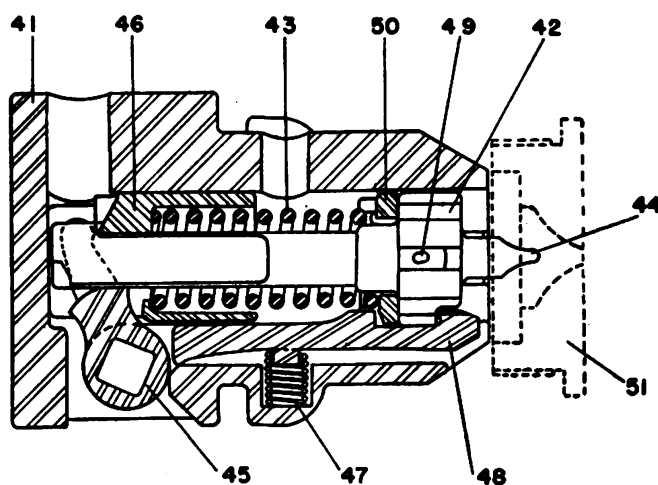


FIGURE 76.—3-inch antiaircraft gun, M3, breech mechanism, left side and rear.

**Q.** How is the breech set for hand operation?—**A.** The clutch on the operating handle is firmly engaged by turning the knurled knob clockwise as far as it will go.

**Q.** When should the breech be set for hand operation for firing?—**A.** Only when the closing spring is not functioning and the operating cam is in its lower notch out of the way. If the handle is engaged when the block is being opened or closed automatically, the whip may break the handle.

**Q.** Describe the operation of the firing mechanism.—**A.** A pull on the lanyard rotates the trigger shaft, which rotates the trigger fork which forces the firing-pin holder sleeve forward, compressing the firing spring. When the sleeve has compressed the spring the desired amount, the front end of the sleeve comes in contact with the slope on



41. Case, firing.

42. Holder, firing pin.

43. Spring, firing.

44. Pin, firing.

45. Fork, trigger.

46. Sleeve, firing pin holder.

47. Spring, sear.

48. Sear.

49. Pin, cotter, 1-inch.

50. Stop, spring.

FIGURE 77.—Firing mechanism, 3-inch AA gun M3.

the side of the sear and forces the sear against its spring and out of contact with the front end of the firing-pin holder. The firing-pin holder, being now released from the sear, flies forward under pressure of the spring. The firing pin strikes the primer in the cartridge case and fires it.

**Q.** Why are the trunnions set so far back?—**A.** To keep the breech well above the platform when the gun is elevated and the breech drops.

**Q.** Why is this desirable?—**A.** For convenience in loading and especially to keep the breech from striking the platform when the gun recoils. If the gun were trunnioned like the M1918 gun, it would be necessary to shorten the recoil at high elevations just as the M1918

gun does. By setting the trunnions close to the breech and using equilibrators, the recoil may be made uniform.

*Q.* Why are equilibrators necessary on this gun?—*A.* To counteract the weight of the muzzle of the gun resulting from the trunnions being so far to the rear.

*Q.* Describe the action of the equilibrators.—*A.* The equilibrator cylinders are filled with air and tend to force the plungers out, which push against the cradle and help elevate the gun.

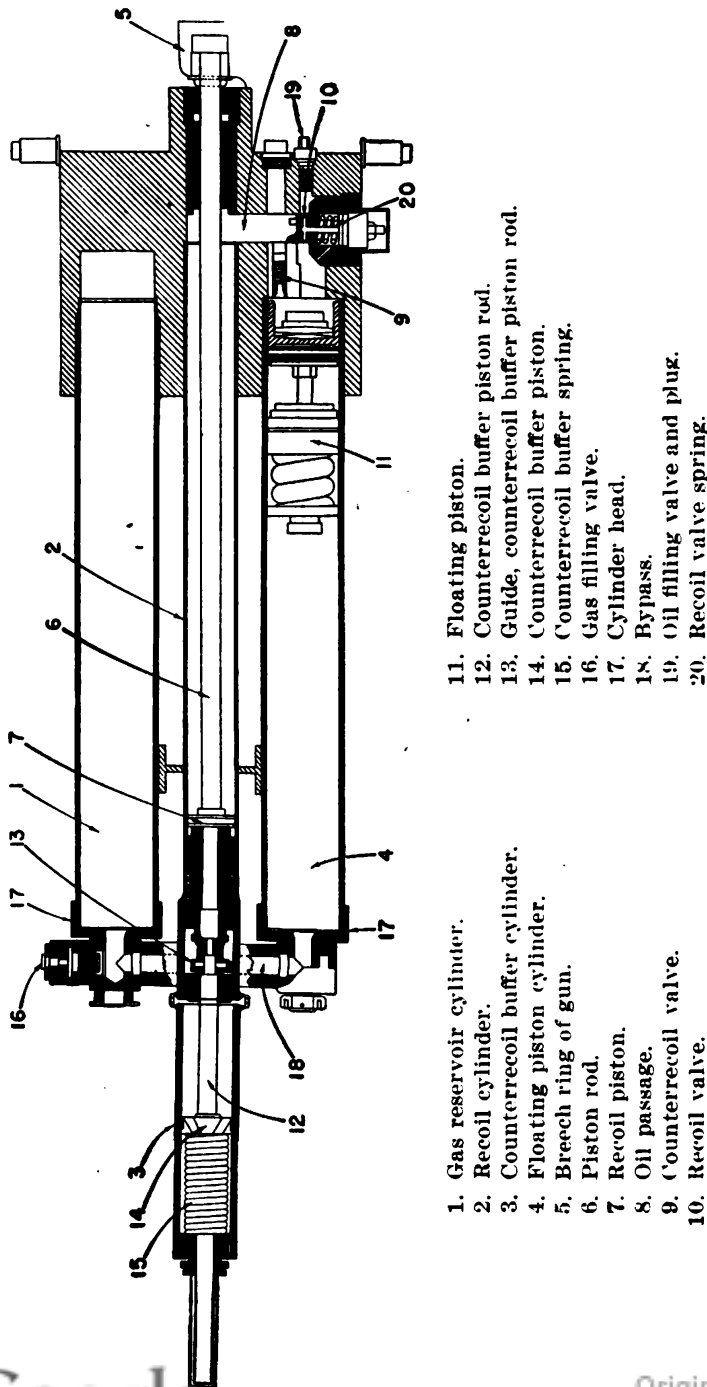


FIGURE 78.—Recoil and counterrecoil mechanism, 3-inch AA mount M2A2.

1. Gas reservoir cylinder.
2. Recoil cylinder.
3. Counterrecoil buffer cylinder.
4. Floating piston of gun.
5. Breech ring of gun.
6. Piston rod.
7. Recoil piston.
8. Oil passage.
9. Counterrecoil valve.
10. Recoil valve.

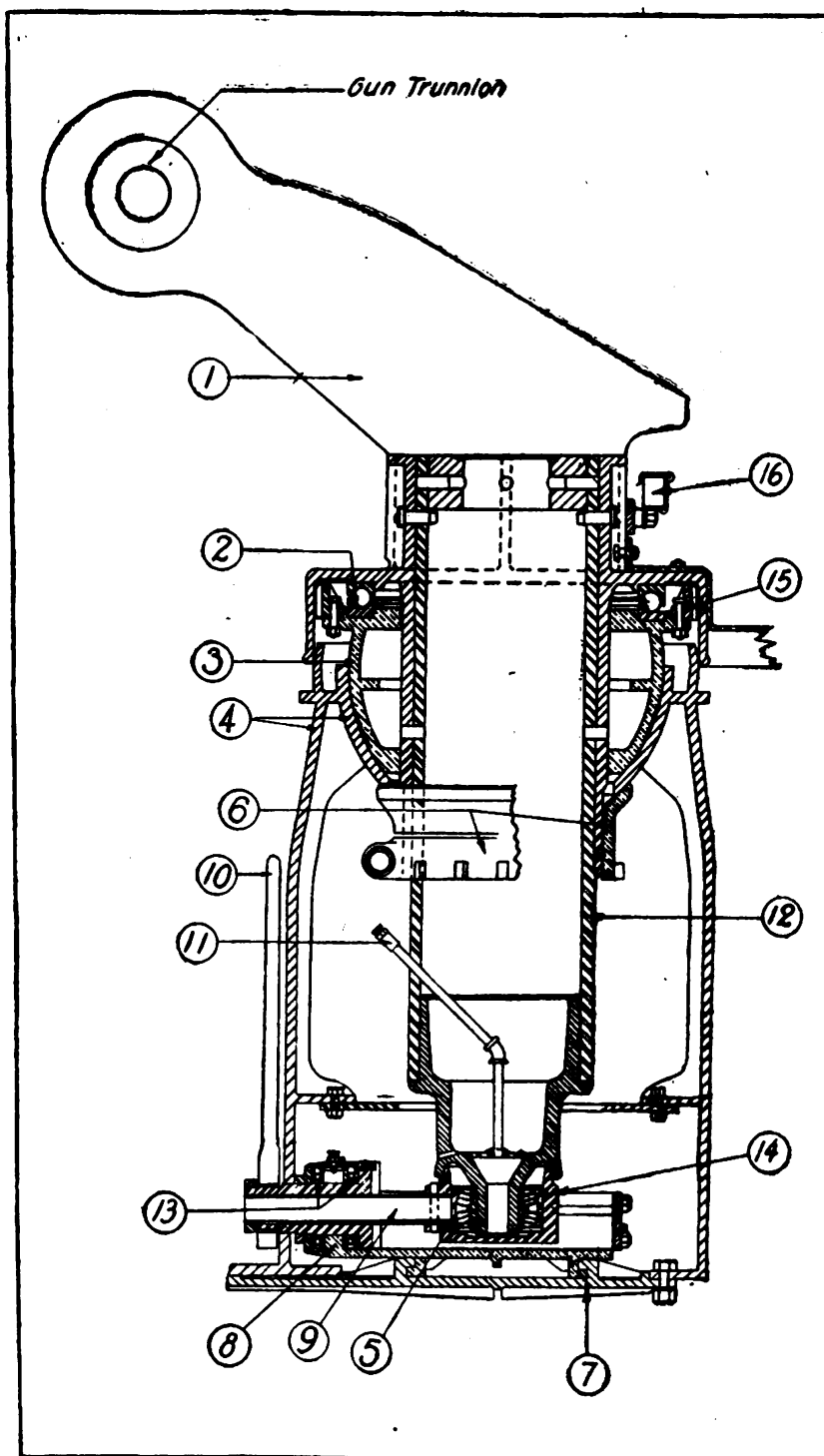
11. Floating piston.
12. Counterrecoil buffer piston rod.
13. Guide, counterrecoil buffer piston rod.
14. Counterrecoil buffer piston.
15. Counterrecoil buffer spring.
16. Gas filling valve.
17. Cylinder head.
18. Bypass.
19. Oil filling valve and plug.
20. Recoil valve spring.

*Q.* Are there any provisions for keeping them from pushing too hard and making it difficult to depress the gun?—*A.* Yes, two. As the plungers are pushed out as the gun elevates, the air pressure behind them decreases. In addition, there are springs in the top of the cylinders which push back on the plungers as they come up and reduce their pressure against the cradle.

*Q.* Describe the operation of the recoil and counterrecoil mechanisms?—*A.* The system when properly charged with gas and oil functions as follows: When fired, the gun and breech ring move to the rear carrying with them the piston rod and the recoil piston, forcing oil out of the recoil cylinder through the oil passage, opening the recoil valve, and throttling the oil through the small orifice thus provided; the oil entering behind the floating piston forces the floating piston forward, compressing the air in the front end of the floating piston cylinder and in the air reservoir. When the gun has recoiled to a length where the energy of recoil has been absorbed, the recoil valve spring closes the recoil valve. The air pressure, now being the greater force, acts on the front of the floating piston driving it to the rear, thus forcing the oil through the counterrecoil valve, thence through the oil passageway in the cradle and into the rear end of the recoil piston cylinder, forcing the recoil piston, piston rod, and gun back into battery. The counterrecoil valve, which is so designed as to allow a rapid passage of the oil, permits the gun to return to battery quickly at all angles of elevation. As the recoil piston nears its "in battery" position, the recoil piston strikes the counterrecoil buffer piston rod forcing the counterrecoil buffer toward the front, causing the oil in the counterrecoil buffer cylinder to flow past the buffer. This action absorbs the remaining energy of counterrecoil, permitting the gun to return to battery without shock.

*Q.* Describe the top carriage.—*A.* The top carriage is of the spindle type, being carried by a ball thrust bearing on the spherical bearing resting in a support in the pedestal. The lower end of the spindle is held by a spherical roller bearing which forms a part of the leveling mechanism. Oil pipes and plugs are provided in the top carriage to permit the lubrication of the traversing thrust bearing. The counterrecoil nut prevents the top carriage lifting during counterrecoil. Attached to the top carriage are the elevating and traversing mechanism, the elevating and traversing receivers, fuze setter, fuze receiver, gun junction box, and the seats for the operators.

*Q.* Describe the leveling mechanism.—*A.* Attached to the base of the pedestal is the base plate, on which a guide is supported. This guide is operated by means of a screw with a ratchet wrench. Held in the guide, at right angles, is a housing which is similarly operated by



- |                              |                          |
|------------------------------|--------------------------|
| 1. Top carriage.             | 9. Screw.                |
| 2. Ball thrust bearing.      | 10. Ratchet wrench.      |
| 3. Spherical bearing.        | 11. Grease pipe.         |
| 4. Pedestal.                 | 12. Spindle.             |
| 5. Spherical roller bearing. | 13. Ball bearings.       |
| 6. Counterrecoil nut.        | 14. Housing.             |
| 7. Base plate.               | 15. Traversing rack.     |
| 8. Guide.                    | 16. Level vial assembly. |

FIGURE 79.-Top carriage and leveling mechanism, 3-inch AA gun M3.

another screw with another ratchet wrench. These wrenches remain attached at all times. The movement of the two screws results in a movement of the top carriage about the center of the spherical bearing. Sufficient movement is provided to permit of  $5^{\circ}$  leveling in all directions. Two level vials at right angles to each other are attached to the top carriage for the guidance of the operator leveling the mount. An alemite lubricator is mounted with a pipe to provide lubrication

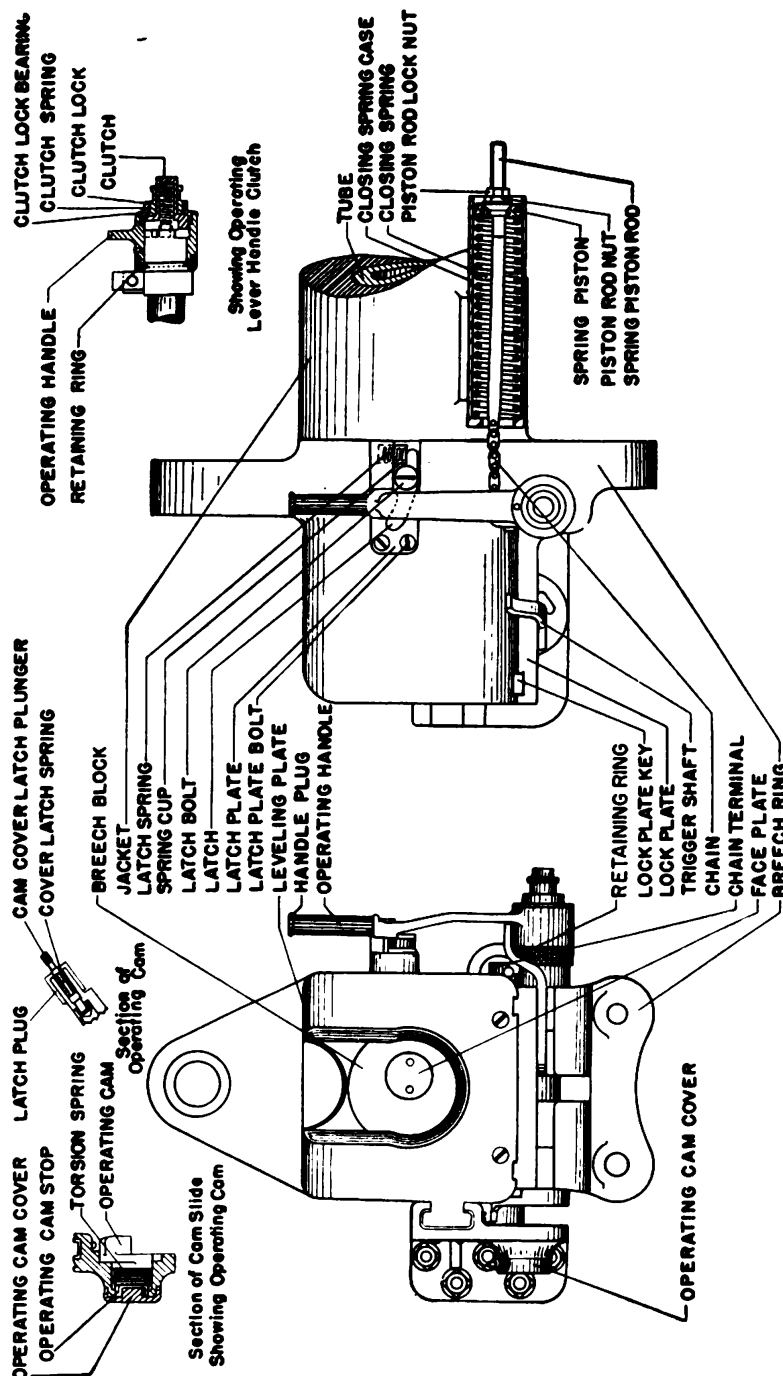


FIGURE 80.—Breech mechanism assembly, 3-inch AA gun M1917.

of the bearing. Alemite fittings are also provided for the lubrication of thrust bearings for each of the leveling screws.

**91. 3-inch antiaircraft gun M1917 (fixed).**—For questions on operation of the breechblock, breech mechanism, and firing mechanism, see M3 gun.

*Q.* This gun is mounted with the trunnions far back. Why are not equilibrators necessary to make elevating easy as in the M3 mobile gun?—*A.* Because the rear end of the cradle is provided with weights to counterbalance the heavy muzzle.

*Q.* What is the length of recoil?—*A.* This gun has a constant recoil of 12 inches.

*Q.* Why is a short recoil possible with this mount?—*A.* Since the mount is fixed and solidly emplaced in concrete, it can be made strong enough to stand the short recoil and there is no danger of overturning.

*Q.* Describe the recoil mechanism.—*A.* The recoil cylinder, of forged steel, is screwed from the front into its seat in the cradle. The piston rod is attached to the gun lug at the rear end and passes through a stuffing box into the cylinder, having at its forward end a bronze piston slightly smaller than the bore of the cylinder.

*Q.* What means is provided to allow the oil to pass from one end of the cylinder to the other as the piston comes back when the gun recoils?—*A.* The inner cylinder wall has three throttling grooves cut lengthwise in it and equally spaced around it. They allow the oil to slip past as the gun recoils. Their depth varies so as to keep the resistance to recoil constant with the aid of the counterrecoil springs, until the gun is brought to a stop in full recoil. The counterrecoil springs take up a small part of the recoil in being compressed. They offer their maximum resistance at the point of full recoil.

*Q.* How much oil does the recoil cylinder hold?—*A.* Six and one-half pints of hydrolene.

*Q.* What means of draining and filling the recoil cylinder are provided?—*A.* A filling hole and plug in the upper part of the cylinder and a drain hole and plug in the lower part.

*Q.* Describe the counterrecoil system.—*A.* The housing for the counterrecoil springs consists of two cylindrical holes bored in the bottom part of the cradle. Each cylinder has an inner and outer spring and a spring rod. The spring rod carries the spring rod piston at its forward end, attached by the spring compressor, and is attached to the gun lug at the rear end by a crown nut and split pin.

*Q.* Describe the counterrecoil buffer.—*A.* It consists of a tapered plunger in the forward end of the recoil cylinder which enters a hole in the forward end of the recoil piston rod. As the tapered plunger enters farther into the hole the clearance becomes less and less, the

oil that is being squeezed out meets more and more resistance, and the gun is brought gradually to rest without jar.

*Q.* What is the principal difference between the recoil system of the M1917 M1 mount and that of the M1917 mount?—*A.* The M1917 M1 mount has four cylinders, two recoil and two counterrecoil. The right-hand upper cylinder is a short cylinder and the left-hand upper is a long counterrecoil cylinder. The lower left-hand cylinder is a recoil cylinder and the lower right a counterrecoil cylinder. Their inside construction and operation is just the same as in the M1917 mount. The M1917 mount has one recoil cylinder at the top of the cradle and two counterrecoil cylinders underneath. Another difference is the length of recoil, the recoil of the M1917 mount being 12 inches while that of the M1917 M1 mount is 16 inches.

*Q.* What device does the M1917 M1 mount have for easy elevating?—*A.* An antifriction device on the trunnions.

*Q.* Describe the antifriction device.—*A.* It consists of a set of Belleville springs that hold the trunnions up in a race of roller bearings, just out of contact with the main bearing surfaces.

*Q.* Describe its action.—*A.* During elevation, since the trunnions bear only on the roller bearings, friction is very low and elevating is easy. When the gun is fired the shock compresses the springs which then let the trunnions down on the main bearing surfaces which take up the greater part of the shock. The springs then immediately lift the trunnions again.

*Q.* In what general way does the M3 mount differ from the M1917 M1 mount?—*A.* It is larger and has a heavier cradle and trunnions to carry the heavier M4 gun.

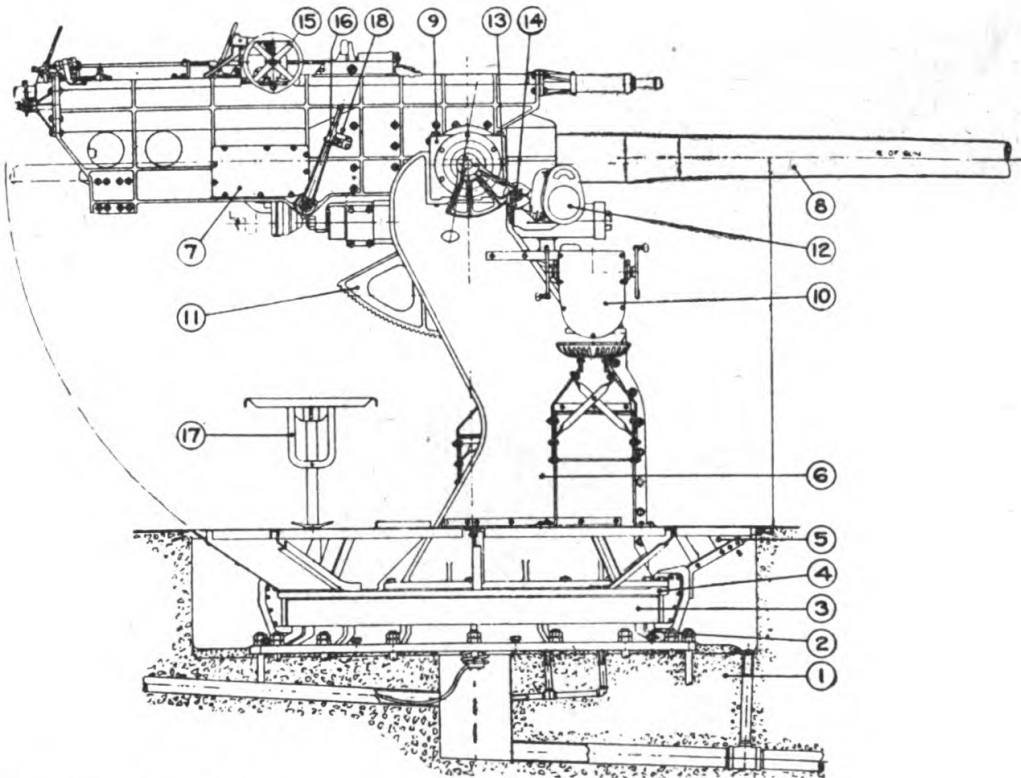
**92. 105-mm antiaircraft gun M3.**—*Q.* Name the principal parts of the M1 mount.—*A.* See figure 81.

*Q.* Explain the automatic operation of the breechblock. *A.*—

(1) Before the first round is loaded the breechblock is opened by pulling the breech operating handle downward and to the rear until the extractors lock the block in the open position, the breech operating handle is returned to its upright position, and the breech operating cam is set for automatic operation of the breech.

(2) When a round is rammed into the chamber of the gun, the rim of the cartridge case strikes the extractors, unlocking the breech and allowing it to be closed by the closing spring. The top surface of the block is beveled toward the breech, thus forcing the cartridge into the chamber as the block rises. The final seating of the cartridge is accomplished by a slight forward movement of the breechblock toward the breech, produced by the rear face and guides of the block which are beveled at a slight angle.

(3) When the gun recoils, the crank on the left end of the operating shaft strikes the upper surface of the operating cam and deflects it in passing. During counterrecoil, the crank on the operating shaft strikes the lower surface of the operating cam, now rigid. This forces the operating shaft to rotate and thereby lower the breech-block. The extractors throw the empty cartridge case to the rear and clear of the mount.



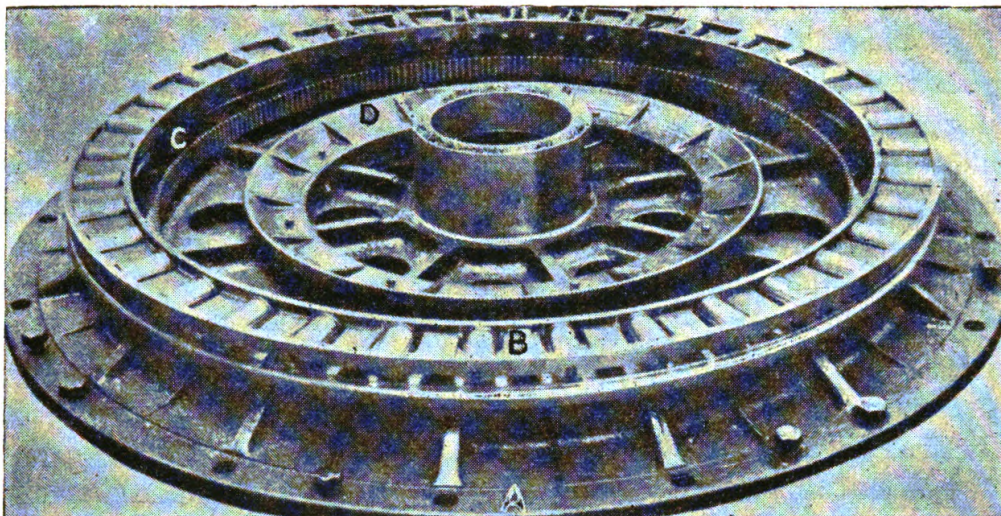
- |                         |                                       |
|-------------------------|---------------------------------------|
| 1. Concrete foundation. | 10. Elevating mechanism.              |
| 2. Base plate.          | 11. Elevating rack.                   |
| 3. Traversing rollers.  | 12. Elevating receiver drive.         |
| 4. Racer.               | 13. Elevating gear segment.           |
| 5. Working platform.    | 14. Elevating gear pinion.            |
| 6. Pedestal.            | 15. Hammer retraction handwheel.      |
| 7. Cradle.              | 16. Breech operating handle.          |
| 8. Gun.                 | 17. Breech operating platform.        |
| 9. Trunnion bearings.   | 18. Latch of breech operating handle. |

FIGURE 81.—105-mm AA gun mount M1 (right side).

Q. Where is the kicker?—A. Between the breech ring and the right cradle extension, mounted on the right side of the breech recess.

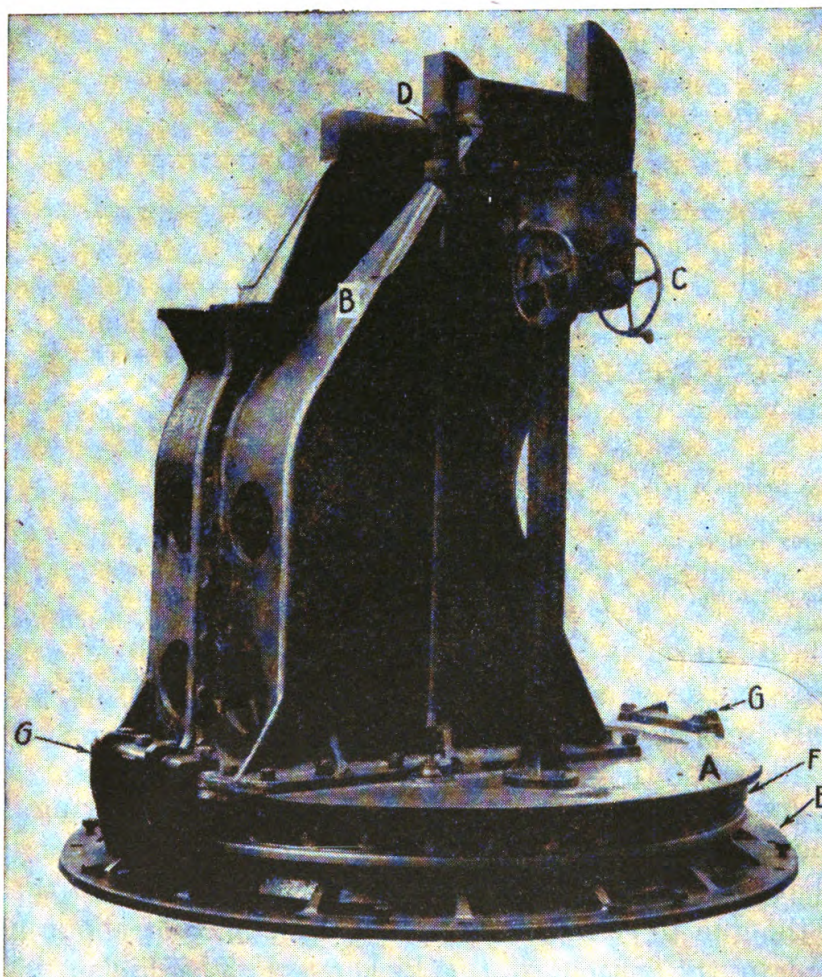
Q. What is the function of the kicker?—A. To utilize the 16-inch recoil of the gun to retract the rammer a distance of about 40 inches.

Q. Explain the action of the kicker.—A. The kicker is pivoted about a stud on the right side of the breech recess. When the gun is loaded, the rammer is in its forward position, and a portion of the bottom of the rammer body is at rest against the shoulder of the fork



- |                     |                  |
|---------------------|------------------|
| A. Base plate.      | D. Azimuth gear. |
| B. Roller assembly. | E. Racer pintle. |
| C. Traversing rack. |                  |

FIGURE 82.—Base plate—roller assembly.



- |                                      |                     |
|--------------------------------------|---------------------|
| A. Racer.                            | E. Base plate.      |
| B. Pedestal.                         | F. Roller assembly. |
| C. Traversing mechanism.             | G. Firing clips.    |
| D. Azimuth receiver drive mechanism. |                     |

FIGURE 83.—Racer—pedestal assembly.

which straddles the rammer body. Upon firing the gun, the kicker moves to the rear with the gun, the fork carrying with it the rammer body. The roller on the lower part of the kicker rides up over a cam on the inner face of the right cradle extension and causes the upper end of the kicker to impart (through the fork) sufficient velocity to the rammer body to throw it the desired distance to the rear.

*Q.* Explain how the rammer is retracted manually.—*A.* The elevation setter lays the piece at a convenient angle of elevation as directed by No. 1. No. 1 holds the lever that engages the retracting pinion and rack, and No. 5, on the breech operating platform.

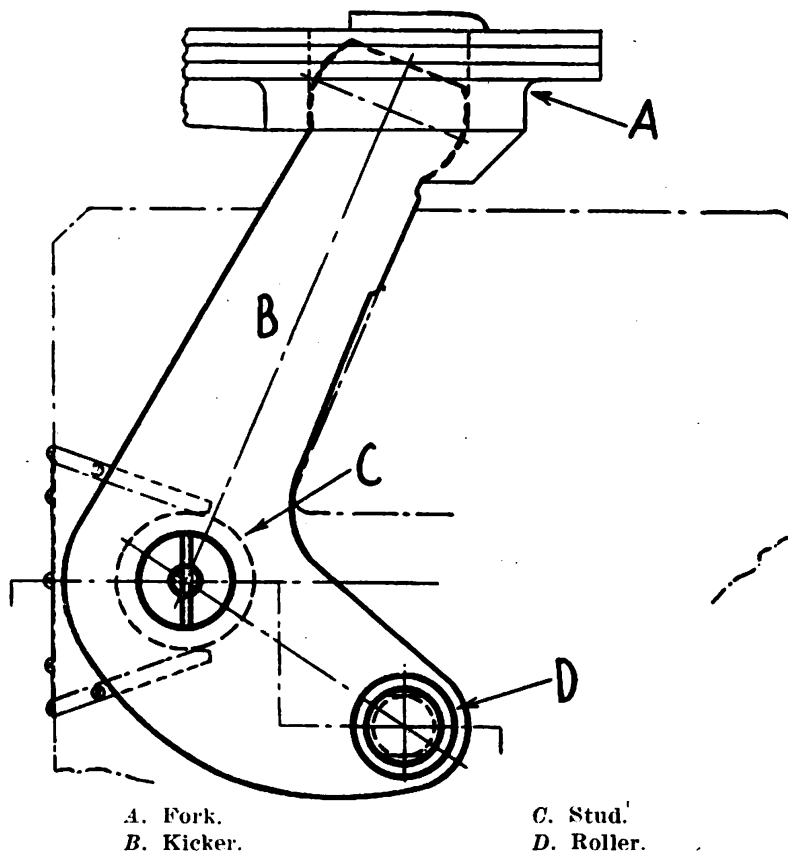


FIGURE 84.—The kicker.

operates the retracting handwheel until the rammer latches back into the sixth notch.

*Q.* What is the purpose of the rammer latch?—*A.* To hold the rammer in the retracted, or loading, position.

*Q.* Why are two rammer release levers provided?—*A.* For convenience in tripping the rammer at various elevations of the gun.

*Q.* What kind of buffers are provided on the ramming mechanism, and what is their purpose?—*A.* Front and rear buffers of the hydro-spring type on the right cradle extension absorb the shock of

stopping the rammer body at the ends of its movement in ramming and retraction.

*Q.* Explain the action of the firing lock T7.—*A.* A pull on the lanyard rotates the trigger shaft and forces the trigger fork (connected with it) forward. The trigger fork in turn forces the firing-pin holder sleeve forward, thereby increasing the compression of the

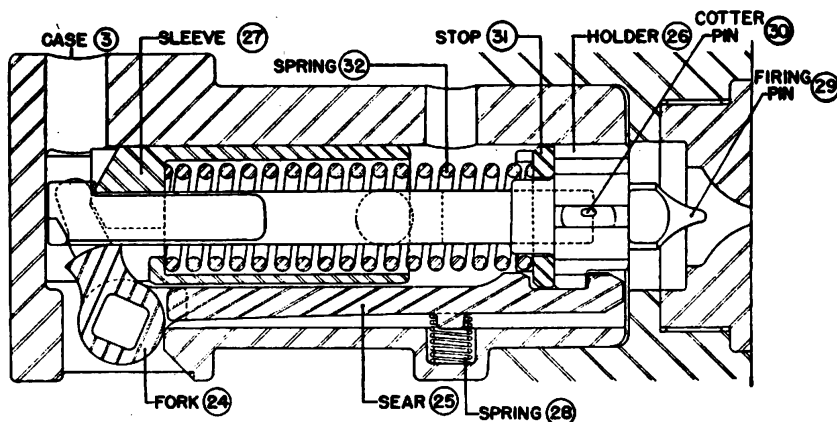


FIGURE 85.—Firing lock T7.

firing spring until the end of the sleeve engages the cam on the spring-actuated sear, presses the latter downward, and releases the firing-pin holder with firing pin assembled. The built-up spring then projects the firing-pin holder forward and fires the piece.

*Q.* Which moves to the rear with the gun in recoil, the recoil cylinder or the piston?—*A.* The recoil piston.

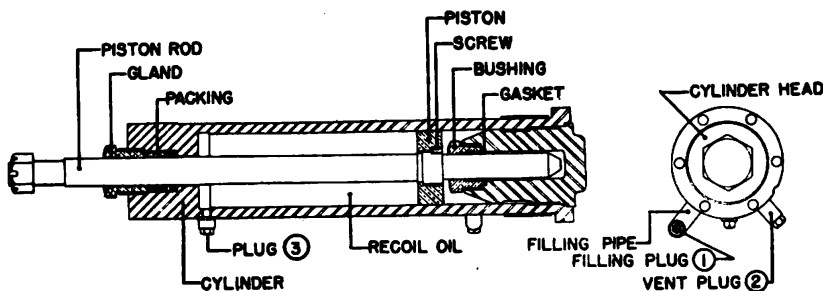


FIGURE 86.—Recoil cylinder.

*Q.* What happens to the oil in space "recoil oil" when the gun recoils?—*A.* When the gun recoils, the recoil piston moves to the rear with the gun and forces the oil in space "recoil oil" into space surrounding "bushing" through the throttling grooves in the cylinder wall.

*Q.* What brings the gun to rest after recoil?—*A.* The depth of the throttling grooves becomes less toward the rear, thereby reducing the area through which the oil is forced as the piston moves to the rear.

The oil is throttled and dissipates a great portion of the energy of recoil. The throttling of the oil and the compression of the springs in the counterrecoil cylinders bring the gun gradually to rest without shock.

**93. Inspection and maintenance.**—*a. 3-inch gun M3.*—*Q.* How is the oil reserve checked and established? *A.*—

- (1) Place gun in horizontal position.
- (2) Remove oil filling plug at left rear of the cradle.
- (3) Insert oil release tool and screw in until oil filling valve is unseated.
- (4) If any reserve oil is present, it will shoot out. When the escaping oil ceases to flow, or the stream drops at right angles to the flow, remove release tool and permit valve seat to close. The proper oil reserve is then established by injecting the contents of an oil screw filler full of oil twice.

(5) If no oil flows through the oil release, an oil reserve must be established by the injection of oil into the recuperator. Remove the plug from the oil filling hole located on the left side of the cradle (visible through a small hole in the top carriage), and pour in heavy recoil oil through a funnel until the cylinder is completely full. Replace the plug, about two turns short of hard home.

(6) Withdraw the piston of the oil screw filler and fill the body of the filler with recoil oil, preventing the loss of oil by holding a finger over the end of the tube. Replace piston and cap. Hold the filler with pipe up and turn the screw until a small amount of oil flows therefrom. This will expel the air from the filler. Place the oil screw filler in the bracket provided at the rear left side of the cradle. Connect the tube of the filler to the oil filling inlet. Turn the handle of the oil screw filler, forcing the oil into the cylinder.

(7) As soon as bubble-free oil starts to emerge from around the lightly screwed-in plug, firmly seat the plug and continue the reserve oil charging until two complete fillerfuls of oil have been forced into the system after the plug has been firmly seated.

*Q.* Explain how to disassemble the breechblock.—*A.* Remove firing case assembly by turning firing case until the locating lugs are disengaged. Remove the screw holding the detent and spring and remove spring and detent.

*Q.* Is bushing in front face of block to be removed?—*A.* Only by ordnance personnel.

*Q.* How is the breechblock reassembled?—*A.* Replace trigger shaft detent into its hole, slip detent handle on, and replace spring and screw. Insert firing case assembly into the breechblock and turn it

until the words "top" on firing case and breechblock coincide. Do not assemble trigger shaft until after block is assembled in gun.

Q. How is the liner removed from the M3 gun? A.—

- (1) Dismount the breechblock.
- (2) Loosen the liner retaining ring by means of the ring wrench.
- (3) Unscrew the retaining ring by hand and withdraw it from the breech.

(4) Insert linked rod of liner muzzle support through liner from muzzle end, and hold in position by hand while the centering plate, followed by washer and nut, is placed over the threaded (breech) end of the rod. The nut is screwed up fairly tight.

(5) Draw the liner slowly to the rear until the front shoulder is to the rear of the breech recess. If liner will not start from its seat in the tube by hand, place a wooden block against head of muzzle support and strike with a heavy hammer to start the liner from its seat.

(6) Raise the liner and insert the liner roller support into the breech recess and lock.

(7) Lower the liner to the roller and draw to the rear, supporting the rear end by hand when the center of gravity of the liner is to the rear of the roller.

Q. What precautions should be taken in removing and installing a liner? A.—

- (1) In extracting the liner the gun should be kept level.
- (2) In removing the retaining ring, care should be taken to prevent the wrench from falling.

(3) The rectangular portion of the linked rod (forward end of threaded portion) must be alined with and enter the rectangular hole in the centering plate before the slack in the rod is all taken up by the nut.

(4) In starting the liner, removing it, setting it down, or driving it in, only wood or bronze should be placed in actual contact with the liner.

(5) Special care must be taken to insure that the liner is not burred or damaged against the shoulders in the tube.

(6) Before inserting in the tube, the liner should be cleaned, inspected, any burrs removed, and the liner greased. Due to the small clearance between the liner and tube, the coating of grease must be very thin, otherwise the liner will not go fully home.

(7) The keys of the liner must be alined exactly with the keyways of the tube as the liner is being inserted. The liner is moved in until the short cross line marked "stop" reaches the rear end of the tube. The liner is then rotated until the longitudinal engraved line

on the top of the liner is alined with the vertical center line on the tube. This will aline the keys and keyways and the liner may then be pushed home.

(8) *Under no circumstances should a liner be removed or replaced against time.*

*Q.* How are the liner and seat lubricated?—*A.* A thin coating of a mixture of 1 pound of No. 3 cup grease and 1 ounce of powdered graphite is applied as the liner is being inserted into the tube.

*Q.* How should the liner be cleaned?—*A.* With gasoline and a cloth that does not shed lint, *not waste*, and dried well with a clean cloth.

*Q.* How are adjustments to take care of changes in temperature made on the equilibrators?—*A.* By turning the squared shaft portion of the worm until the gun elevates and depresses easily.

*Q.* Who checks the air pressure in the recoil system?—*A.* Ordnance personnel only.

*b. 3-inch gun M1917.—Q.* How is the breech mechanism disassembled? *A.—*

- (1) Remove the trigger shaft detent pin and the trigger shaft.
- (2) Screw in the clutch and open the breechblock.
- (3) Remove the plunger plugs and the extractor plungers and their springs.
- (4) Place clip over the spring piston rod just forward of its connection with the chain, and clamp it tightly to the rod.
- (5) Trip the extractors with an empty cartridge case and allow the breechblock to close slowly, controlling the speed of closing and completing the closing by use of the operating handle.
- (6) Twist the chain upward and forward out of the way and remove the locking plate by pulling to the rear.
- (7) Screw an eyebolt in the top of the breechblock and attach a rope to it.
- (8) Remove the lock screw for the retaining ring, turn the retaining ring clockwise until the operating handle is free, and remove the handle.
- (9) Raise the breechblock and at the same time have the operating lever pushed as far to the rear as the breechblock will allow. The breechblock is pulled up as far as it will go and the operating lever is removed from its seat.
- (10) With two men below to catch it as it drops clear, lower the breechblock completely out of the breech recess.
- (11) Pull up the cam cover latch plunger and turn the operating cam cover counterclockwise until the cover latch plunger rests in the notch provided for it.

(12) Pull the plunger out and remove the cam cover by pulling it straight away from its seat.

(13) Push the operating cam with the torsion spring from its seat. Twist the cam into a position similar to that for hand operation and push it all the way out.

*Q.* How is the firing mechanism disassembled? *A.*—

(1) With the trigger shaft removed, unscrew the face plate on the breechblock and draw out the firing-pin holder assembly.

(2) Remove the sear and sear spring, drawing them into the firing-pin hole.

(3) Separate the parts of the firing-pin holder assembly by inserting the flat end of the trigger shaft in the slot of the firing-spring shoe and pushing it down, turning the shoe to the left (counterclockwise) to disengage the lug on the shoe from the slot in the firing-pin holder; then allow the firing spring to push the shoe out.

*Q.* How often should the recoil cylinders be drained and refilled?—*A.* At least once every 3 months.

*Q.* How are the recoil cylinders drained and refilled? *A.*—

(1) To drain, remove the filling and drain plugs and let the oil drain out.

(2) Replace the drain plugs tightly; place the gun in a horizontal position, and fill the recoil cylinders through the filling hole with light recoil oil. Leave a void in the cylinder of not more than one-fourth of a pint of oil to allow for expansion as the oil becomes heated during firing.

*c. 105-mm gun M3.*—*Q.* What kind of oil is used in the recoil cylinder?—*A.* Low-pour-point recoil oil.

*Q.* How much oil does the recoil cylinder hold?—*A.* Fifteen pints.

*Q.* What kinds of oil and grease are used in the lubrication of the gun and mount?—*A.* Class D lubricating oil, mineral lubricating grease, and medium lubricating graphite grease.

*Q.* How often should the various parts be lubricated?—*A.* In general, gear cases and other components packed with grease at assembly should be cleaned and repacked once every 6 months of continuous service. Other moving parts should be oiled with class D oil daily when in constant use.

*Q.* How are lubrication fittings marked?—*A.* They are painted bright red.

*Q.* In what position should the rammer be when the air pressure is measured?—*A.* In the forward position.

*Q.* What should the air pressure be when the rammer is in this position?—*A.* When the gun is cool (not recently fired) the reading should be approximately 80 pounds per square inch. If the gun is

well warmed up from firing, the pressure should be approximately 90, and may reach 95 pounds. Pressure higher than 95 pounds should be relieved.

*Q.* What should be done to the pressure gage cock before firing?—

*A.* The cock should be closed so that the high pressure built up when the rammer is retracted will not damage the gage.

*d. Guns—general.—Q.* How is rust softened?—*A.* By using gasoline and scraping with a piece of wood.

*Q.* How can oil that has become dry and gummy be loosened?—*A.* By using gasoline.

*Q.* How can oil holes that have become clogged be opened?—*A.* They may be opened with a piece of wire. Wood should never be used for this purpose as splinters are likely to break off in the holes.

*Q.* Are parts of the gun affected by gas?—*A.* Yes, by certain kinds of gas. As a precaution, bright parts should be coated with oil.

*Q.* How should the bore be cleaned after firing?—*A.* It should be sponged thoroughly with a solution of one-half pound of soda ash or 1 pound of sal soda to a gallon of boiling water. The bore should then be dried thoroughly with pieces of burlap and well oiled.

*Q.* How should the breechblock be cared for?—*A.* All mechanisms should be disassembled and inspected for rust frequently; cleaned thoroughly with gasoline and waste, rag, or brush; and well oiled with class A lubricating oil.

*Q.* When should the rust-preventive compound be used?—*A.* When the gun is to be stored or not used for a long time.

*Q.* What should be done after matériel has been painted several times and old paint is thick or cracked?—*A.* Paint should be removed by the use of paint-removing solution and scraping. The solution is made by adding to 6 pints of hot water, 1 pound of powdered lye, and enough lime to make solution as thick as paint. Apply fresh to painted surfaces and scrape paint off when soft. Before repainting, wash the surface with soda ash water, rinse with clean water, and dry thoroughly.

*Q.* How should exposed portions of mechanism not painted be treated?—*A.* Thoroughly cleaned and covered with a thin film of grease.

*Q.* What care should be taken of oil holes and grease cups when painting?—*A.* See that paint does not get inside of them. Grease cups should be painted red and oil holes should have a red circle around them. Alemite fittings should be painted red but the openings must be kept clear.

*Q.* What precaution is taken to prevent dirt and other matter from entering the recoil cylinders?—*A.* Clean funnels are used and the oil is strained through cheesecloth.

*Q.* What is the effect of rapid fire on the recoil cylinder oil?—*A.* It heats up and expands and the gun may not return fully into battery.

*Q.* How are the recoil cylinders drained?—*A.* Remove the drain plugs from the top and bottom of the cylinder and let the oil run out.

*Q.* How often should they be drained?—*A.* At least every 3 months.

*Q.* How often should they be cleaned?—*A.* Once every 6 months, by an ordnance mechanic.

**94. Fuze setters.**—*a. M8 fuze setter.*—*Q.* Explain the operation of the continuous fuze setter M8. *A.*—

(1) One turn of the setting crank causes the setting ring to make two revolutions. During the first revolution pawls on the setting ring arrive at and engage the slot in (or lug on) the body of the fuze and begin to rotate the round.

(2) The adjusting ring, meanwhile, has been positioned according to the fuze setting indicated by the director. During the second revolution of the setting ring the lug or slot in the setting element of the fuze will arrive at and be stopped by the pawls on the adjusting ring.

(3) The setting ring continues to turn the projectile until the second revolution is completed, when a stop pawl terminates the movement. In this position the body of the fuze has been stopped at what might be called a "zero position," while the setting element of the fuze has been stopped at a point the proper number of graduations away from the zero position, and the fuze is said to be "set."

*Q.* How is the M8 fuze setter adapted for different types of ammunition?—*A.* The case and the body are hinged, and by loosening the wing nut holding the two together, it is possible to swing the body away from the case, giving access to the adjusting and setting rings. Three sets of rings are provided, one for the 21-second powder train fuze, one for the 30-second mechanical fuze, and one for use with dummy cartridges. The rings are easily changed, and cannot be assembled improperly because the screw holes in the rings are spaced differently. For the two different time fuzes, different range scales for the face of the fuze indicator are provided.

*Q.* How are the adjusting and setting rings of the M8 fuze setter changed? *A.*—

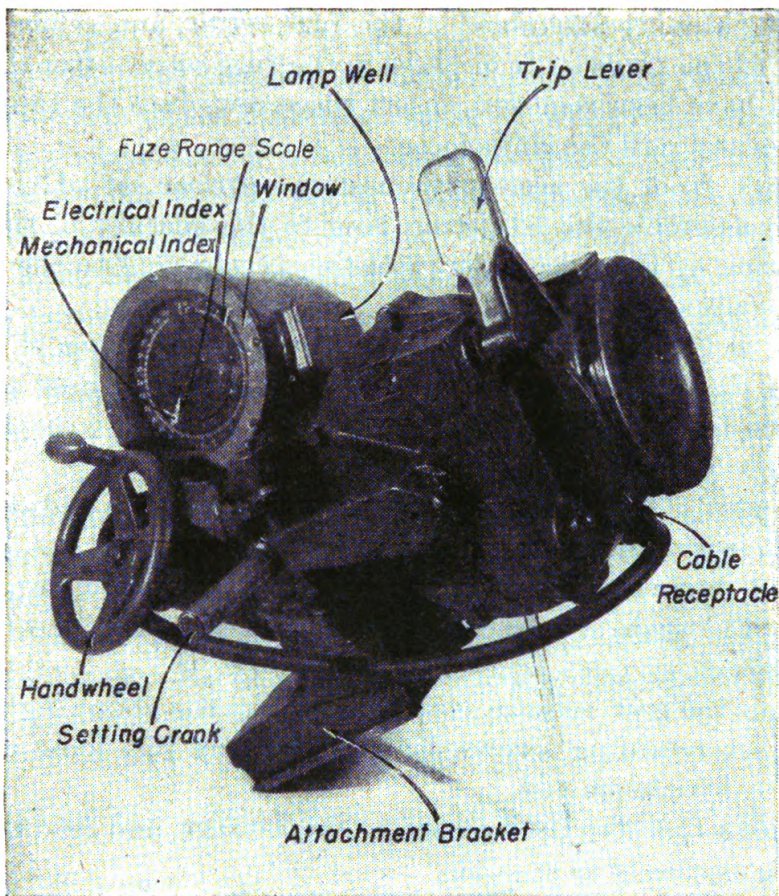


FIGURE 87.—M8 fuze setter.

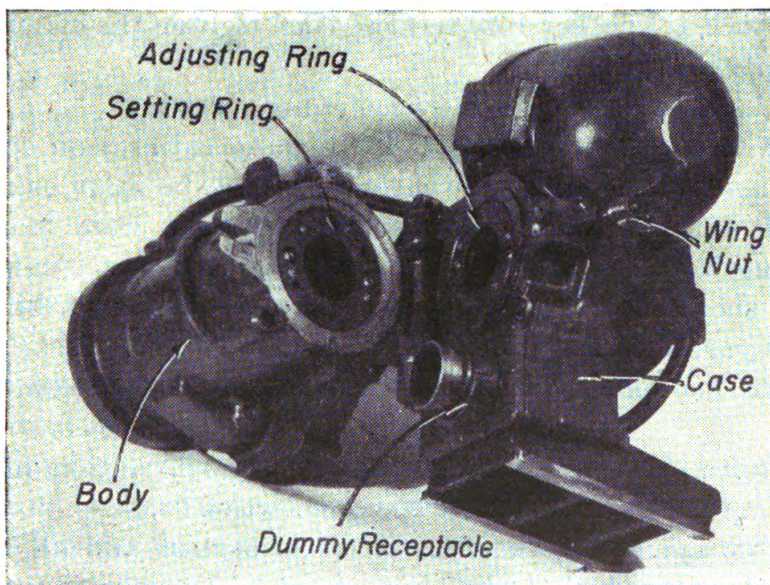


FIGURE 88.—M3 fuze setter opened for inspection.

(1) Open the fuze setter, remove the screws and the lock washers in each ring already assembled in the fuze setter, and remove this set of rings. If the rings stick in place in the fuze setter after the fastening screws have been removed, insert the screws into the tapped holes in the rings and pull the rings loose.

(2) Select from the accessory chest the proper set of rings to be used; then assemble the adjusting ring to the adapter in the case or lower portion of the fuze setter, and the setting ring to the socket in the body or upper portion.

*Q.* How is the fuze range scale of the M8 fuze setter changed?—

*A.* In case the fuze range scale on the fuze indicator does not correspond to the fuze to be used, the scale must be replaced with the proper one from the accessory chest.

(1) Carefully remove the window frame from the indicator face, so as not to injure the gasket.

(2) Next remove the six screws and the ring which clamp the scale in place. The scale should be removed and placed in the lid of the accessory chest.

(3) Place the new scale in position, replace the clamping ring, and insert the six retaining screws, leaving the ring just loose enough to allow the scale to be moved.

(4) Place a round in the fuze setter, set the fuze, and read the setting on the fuze as closely as possible.

(5) Insert a blunt point in the hole in the scale over the zero and slide the scale around under the ring until the value set on the fuze is opposite the indicating marks on the outer or mechanical index.

(6) Recheck at another fuze setting, then tighten the clamping ring screws evenly and firmly.

(7) Replace the window and its fastening screws.

*Q.* What is the primary reason for placing calibration corrections on the electrical dial?—*A.* So that a fuze may be more easily set to "safe." If a mechanical calibration adjustment were made, some other setting would have to be indicated to cut a fuze to "safe."

*Q.* How should the fuze setter be cleaned?—*A.* By flushing its interior with gasoline and operating the handles. If it works all right, a little light machine oil should be poured in and allowed to spread around.

*b. M9 fuze setter.—Q.* What cleaning and lubrication of the M9 fuze setter is done by members of the gun section? *A.*—

(1) Before operation, the fuze setter is opened and all accessible parts are cleaned with clean, lint-free cloths.

(2) Oil holes and all moving surfaces in contact, including hooks, levers, latches, and plungers are oiled with light lubricating oil.

(3) Interior parts not accessible are flushed out with the lubricating oil through vents.

*Q.* Is it necessary for members of the firing section to repack the ball bearings in the hub of the indicator bracket? *Why?*—*A.* No. These bearings are packed during initial assembly and should not require further attention for several years. When repacking is necessary, it is done by ordnance personnel.

*Q.* How is the fuze setter checked for backlash? *A.*—

(1) Set a particular value on the indicator by turning the adjusting handwheel clockwise.

(2) Set a fuze, remove the round from the fuze setter, and read the setting of the fuze.

(3) Reset the indicator by turning it past the original setting in the same direction as before (clockwise), then returning to the original setting by turning the handwheel counterclockwise.

(4) Set a fuze again and read the setting.

(5) The difference between the two readings of the fuze is the amount of backlash. Backlash should not exceed one-tenth second.

## SECTION II

### DUTIES OF MEMBERS OF FIRING SECTION

Ability to instruct members of gun section..... Paragraph 95

**95. Ability to instruct members of gun section.**—The candidate should be required to demonstrate practically his ability to instruct members of the gun section in drill at the gun and in the emplacement of the gun. Duties of members of the gun section are outlined in TM 4-325.

## SECTION III

### AMMUNITION—BASIC

Storage and care..... Paragraph 96  
Preparing projectiles for firing..... 97

**96. Storage and care.**—*Q.* What is a magazine?—*A.* A place where ammunition is stored.

*Q.* What kind of magazine is most desirable for storing AA ammunition?—*A.* Any magazine which gives good protection against the weather will answer for storing fixed ammunition if no better is available, but it is very important to secure a fireproof magazine if possible.

*Q.* Are basements or attics of barracks or battery supply rooms suitable for the storage of ammunition?—*A.* No. Neither should

ammunition be stored in buildings which are used for any other purpose.

*Q.* If there are no cleats on the ammunition chests, how should they be piled?—*A.* With strips of loose material between layers to allow air to circulate freely between the chests. In any case, the bottom layers should be raised 2 inches off the floor to give protection from dampness. Piles should not extend beyond the eaves nor too near the higher temperatures close under the roof, and should be neat and stable with aisle space between rows to allow for easy inspection and checking.

*Q.* When rounds are returned unfired from the guns, what should be done with them?—*A.* They should be replaced in their containers and the containers resealed with strips of friction tape and shellac before they are replaced in storage. They should never be left loose in the magazine.

*Q.* What should be done with ammunition chests in the magazine in which unused rounds are replaced?—*A.* They should be closed tightly with lids fastened down to prevent any tampering. If only partly filled, they should be plainly marked and placed in a conspicuous place on top of the piles.

*Q.* If ammunition chests need repairs, where should this be done?—*A.* In an empty magazine or out of doors away from all ammunition.

*Q.* How can the fire hazard be cut down?—*A.* By keeping all unnecessary inflammable material such as excess dunnage, wood, waste, or rags out of the magazine and keeping the area all around and in the near vicinity of the magazine free from dry grass, leaves, piles of wood, trash, and all other inflammable materials. Whatever fire protection is available such as extinguishers, hose, buckets, and water supply system, should be kept in good working order at all times. Any defects should be promptly remedied or reported.

**97. Preparing projectiles for firing.**—*Q.* How should a projectile be prepared for firing?—*A.* It should be removed carefully from the container, fuze cap removed, and paint and wax cleaned off the nose in rear of the fuze.

*Q.* Why is it necessary that all foreign matter be removed from the nose of the projectile?—*A.* Dirt is liable to clog up the fuze setter and cause erratic fuze settings.

*Q.* How many projectiles should be prepared and where are they placed?—*A.* Only as many as are expected to be fired. These are placed on the ammunition tables and covered with a tarpaulin to protect them from the sun and dirt.

*Q.* What should be done with empty cases after firing?—*A.* They should be washed thoroughly in sal soda solution immediately after

the firing, rinsed in clean water, and repacked in boxes for turning back to the Ordnance Department.

**Q.** Should battery personnel be permitted to take down or alter any AA fuze?—**A.** No. The handling of a fuze by inexperienced personnel is dangerous. The practice of inserting a punch in a fuze cap wrench notch and hammering to loosen the cap, thereby shearing the fuze cap lock, is dangerous and is prohibited.

## SECTION IV

### PREPARATION FOR SERVICE PRACTICE

|                               | Paragraph |
|-------------------------------|-----------|
| 3-inch gun M3.....            | 98        |
| 3-inch gun M1917 (fixed)..... | 99        |
| 105-mm gun M3.....            | 100       |

**98. 3-inch gun M3.—Q.** What checks of the gun and mount should be made after it has been emplaced? **A.—**

- (1) The gun should be accurately leveled.
- (2) There should be no rocks or unyielding substances under the pedestal spade or outriggers.
- (3) The outriggers should bear only lightly on the ground as they are not intended to take the shock of firing.

(4) The lifting jacks should be fully raised.

**Q.** What mechanisms on the gun and carriage should be checked? **A.—**

- (1) The fuze setter should be checked by actually setting a fuze.
- (2) The breech and firing mechanism should be examined and tested.
- (3) Recoil cylinders should be checked and filled if necessary.
- (4) The gun should be elevated, depressed, and traversed to insure ease of functioning.
- (5) The bore should be cleaned.
- (6) The operation of the breech operating cam should be checked.
- (7) Functioning and setting of the equilibrators should be checked.

**Q.** What other preparations should be made? **A.—**

- (1) All lighting arrangements for scales should be checked.
- (2) Calibration corrections, if any, should be properly applied.
- (3) Ammunition should be cleaned and prepared for firing.
- (4) The electrical data transmission system should be checked.
- (5) The director and guns should be bore sighted and oriented together.

(6) Setting of all transmitters and receivers should be checked against each other.

(7) The elevation mechanical pointer should be checked with a quadrant.

*Q.* What other checks, not directly the responsibility of the gun commander, should be made? *A.*—

(1) The director should be checked for accuracy of functioning.

(2) The BC telescope, height finder or altimeters, and other fire-control instruments should be adjusted and checked.

*Q.* During firing what are the responsibilities of the gun commander? *A.*—

(1) To supervise the work of the gun section.

(2) To stop the gun from firing in case bursts appear more than one-half the distance up the tow line.

(3) To supervise the traversing of the gun and require a wait of 10 minutes in case of a misfire.

(4) To see that all misfired rounds are withdrawn and set at "safe" in case "Cease firing" is given.

*Q.* What are the duties after each course and after firing? *A.*—

(1) To note the number of rounds fired in each course and have the empties piled away from the gun.

(2) To clean the gun and empty cartridge cases.

(3) To put away empty cartridge cases and unfired rounds.

(4) To furnish the executive with information to be entered in the gun book.

**99. 3-inch gun M1917 (fixed).**—The same questions apply for this gun as for the M3 gun except that the gun is permanently emplaced.

**100. 105-mm gun M3.**—In general, the same questions apply to this gun as to the M3 gun except that it is on a fixed mount.

*Q.* What additional checks should be made of this gun before firing? *A.*—

(1) Check working of breech operating and rammer tripping cams.

(2) Check air pressure in rammer cylinder.

## SECTION V

### POINTING AND FIRING

|  | Paragraph |
|--|-----------|
| Method of firing trial shots.....                                  | 101       |
| Purpose and procedure in calibration and verification firings..... | 102       |
| Bore sighting and orientation.....                                 | 103       |

**101. Method of firing trial shots.**—*Q.* What is the purpose of firing trial shots?—*A.* To determine corrections for unknown non-standard conditions existing at the time.

**Q.** When should they be fired?—**A.** As short a time as possible before fire at the target is expected. In time of war they should be fired at various times throughout the day, ordinarily at early morning, near noon, and at dusk, if permitted.

**Q.** How is the gun laid for the firing of trial shots?—**A.** Director and guns having first been accurately oriented together, all corrections are set into director and a corrected azimuth, elevation, and fuze range are transmitted to the data receivers at the gun. Pointers are matched and the quadrant elevation is checked with the gunner's quadrant.

**Q.** How is the correction of the fuze setting verified?—**A.** Each fuze is carefully checked after it is set and, if necessary, is reset until the correct setting is indicated on the fuze itself.

**102. Purpose and procedure in calibration and verification firings.—Q.** What is the purpose of calibration firings?—**A.** To determine the corrections to cause all guns to shoot parallel.

**Q.** How is calibration fire conducted? **A.—**

(1) Select the calibration point, a trial shot point.

(2) Remove all corrections from individual guns.

(3) Lay the guns by quadrant.

(4) Fire a cleaning round from each gun.

(5) Fire five rounds from each gun. The guns should be fired alternately so that conditions may be as nearly the same as possible for each.

(6) Locate and plot each burst by the most accurate method available.

(7) Either determine the center of burst for the battery or decide on a base piece and bring all other centers of bursts to this point.

(8) Place the corrections on the individual guns. Keep a careful record of these.

(9) Use these corrections for all firings and do not remove them until another calibration problem is to be fired.

**Q.** How often should calibration firings be conducted?—**A.** Whenever there is undue dispersion in the battery or new guns are received. Also when a gun is replaced in a battery.

**Q.** What is the purpose of verification fire?—**A.** To show errors in orientation, errors in synchronism, large calibration errors, and to check the general functioning of the whole position-finding system.

**Q.** What is the procedure in verification fire?—**A.** A burst is placed in the sky by one gun. It is tracked by the complete position-finding system and all guns of the battery fired at this burst.

**Q.** How often should verification fire be conducted?—**A.** As often as there is any question as to the synchronization of the system. Fire of this kind is a valuable check at any time.

**103. Bore sighting and orientation.**—*Q.* What is the purpose of bore sighting?—*A.* Bore sighting has for its purpose orientation of the guns and the director.

*Q.* Why are guns and directors oriented?—*A.* Orientation has for its purpose the adjustment of the azimuth circle or scale of the gun or director so that the azimuth in which the gun or director is pointed, when set at any position, will be indicated on the azimuth circle or scale. Conversely, the correct orientation of the azimuth circle of the gun or director permits the laying of the gun or director in any desired direction indicated in terms of azimuth.

*Q.* What is used as an orienting point?—*A.* Terrestrial data points can be used. All guns are bore sighted on the datum point and the azimuth index or the mechanical pointer on the receiver is set at the known data; likewise all instruments are oriented on the same datum point.

*Q.* Explain the method of orientation in azimuth. *A.*—

(1) Level the gun.

(2) Bore sight the gun on a datum point, using the bore sight in the breech and a vertical string centered across the muzzle as a line of sight.

(3) Hold the gun stationary with the axis of the bore alined on the datum point. Raise the sliding cover on the left side of the azimuth indicator and, raising the detent engaged in the toothed wheel, turn the toothed wheel until the mechanical (outside) dials read the azimuth of the datum point.

(4) Release the detent and close the cover.

(5) Check the reading and the alinement of the gun on the datum point and readjust them if necessary.

*Q.* Explain the method of orientation in elevation. *A.*—

(1) Level the gun and set it at any convenient elevation, such as 800 mils, by means of the gunner's quadrant.

(2) Hold the elevation wheel stationary. Raise the sliding cover on the left side of the elevation indicator. Raise the detent engaged in the toothed wheel and turn the wheel until the mechanical (outside) index reads the elevation of the gun.

(3) Release the detent and close the cover.

(4) Check the gun at several other elevations and readjust if necessary.

*Q.* What other major matériel adjustments must be checked?—

*A.* The synchronization of the data transmission units.

*Q.* How are the guns synchronized?—*A.* Synchronization is effected by turning the electrical synchronizing screws until the points on the

electrical dials read the same values that the director is transmitting. The electrical synchronizing screw (for fine dial) will be found at the bottom of the recess under the sliding cover on both the azimuth and elevation indicators. On the fuze setter the electrical synchronizing screw is in the lamp well on top of the fuze range indicator. Remove the six screws holding the cover of the lamp well.

## CHAPTER 6

## ANTIAIRCRAFT GUN RANGE SECTION

|   | Paragraphs |
|---|------------|
| SECTION I. Duties of members of range section.....      | 104        |
| II. Elementary gunnery.....                             | 105-108    |
| III. Records and reports; analysis of target practice-- | 109        |

## SECTION I

## DUTIES OF MEMBERS OF RANGE SECTION

|   | Paragraph |
|---|-----------|
| Ability to instruct members of range section..... | 104       |

**104. Ability to instruct members of range section.**—The candidate should be required to demonstrate practically his ability to instruct members of the range section in their duties. Duties of members of the range section are outlined in TM 4-325.

## SECTION II

## ELEMENTARY GUNNERY

|   | Paragraph |
|---|-----------|
| Explanation of corrections necessary to obtain final firing data..... | 105       |
| Computation of corrections based on trial shot firings.....           | 106       |
| Effect on flight of projectile of nonstandard conditions.....         | 107       |
| Purpose of trial, verification, and calibration firings.....          | 108       |

**105. Explanation of corrections necessary to obtain final firing data.**—*Q.* In what ways may a point in space (the sky) be located with reference to an observer on the ground? *A.*—

(1) By the value of the angle between the horizontal and line of position (angular height) and the distance along the line of position (slant range).

(2) By the distance along the two sides of a right triangle (horizontal range and altitude).

(3) By angular height and horizontal range.

(4) By angular height and altitude.

In each case the point is definitely located when the azimuth is also determined.

*Q.* What combination is generally used to locate the target as a basis for determining the firing data?—*A.* Angular height, altitude, and azimuth.

*Q.* If the gun is set at this angular height and azimuth, the fuze set for this slant range, and the gun fired, will the projectile hit the

point in space?—*A.* No. The projectile would drop down in a curve due to gravity and would pass to the right laterally due to drift. Also, it would probably be changed from its course because of the effects of wind, nonstandard density, nonstandard powder temperature, and inaccurate knowledge as to the muzzle velocity developed by the guns.

*Q.* Explain what elements make up the final firing data to hit a fixed point in space. *A.*—

(1) *Elevation.*—The angular height, to which is added a correction for the curvature of the trajectory called the superelevation and a second correction to take care of wind, nonstandard density, powder temperature, and muzzle velocity. The sum of these is called the quadrant elevation.

(2) *Azimuth.*—The azimuth must be corrected to take care of wind and drift.

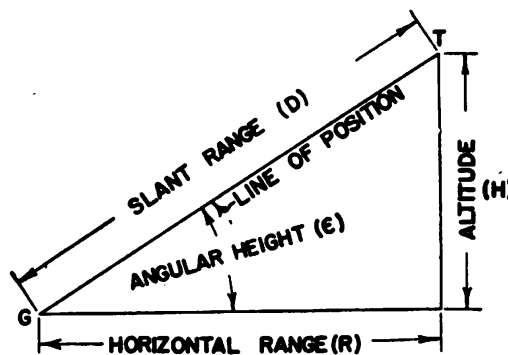


FIGURE 89.—Location of point in space.

(3) *Fuze range.*—The fuze range must be corrected since its value is also affected by nonstandard conditions.

*Q.* How are these data improved for firing at a moving target?—*A.* To the quadrant elevation is added the vertical deflection to take care of the vertical travel of the target during the time of flight, the result being the quadrant elevation to the future position. To the azimuth is added the lateral deflection to take care of the lateral travel of the target during the time of flight. The result is the future azimuth. For the fuze range the time of flight used is that to the future position.

*Q.* What is a trajectory chart?—*A.* A side view of the path of the projectile for various elevations under standard conditions.

*Q.* What are some of these standard conditions? *A.*—

- (1) No wind.
- (2) Muzzle velocity as listed.
- (3) Certain density conditions exist.

(4) The following temperature conditions exist: temperature at battery 59° F. and temperature of powder 70° F.

(5) Weight of projectile as listed.

(6) Drift a certain previously determined value.

Q. From what data are the curves on trajectory charts drawn? Where are these data found?—A. From trajectory data for the proper gun and ammunition found in the firing tables for that matériel.

Q. Does the same trajectory chart apply for all guns?—A. No. Each chart pertains to a particular gun using a certain type of projectile and fuze.

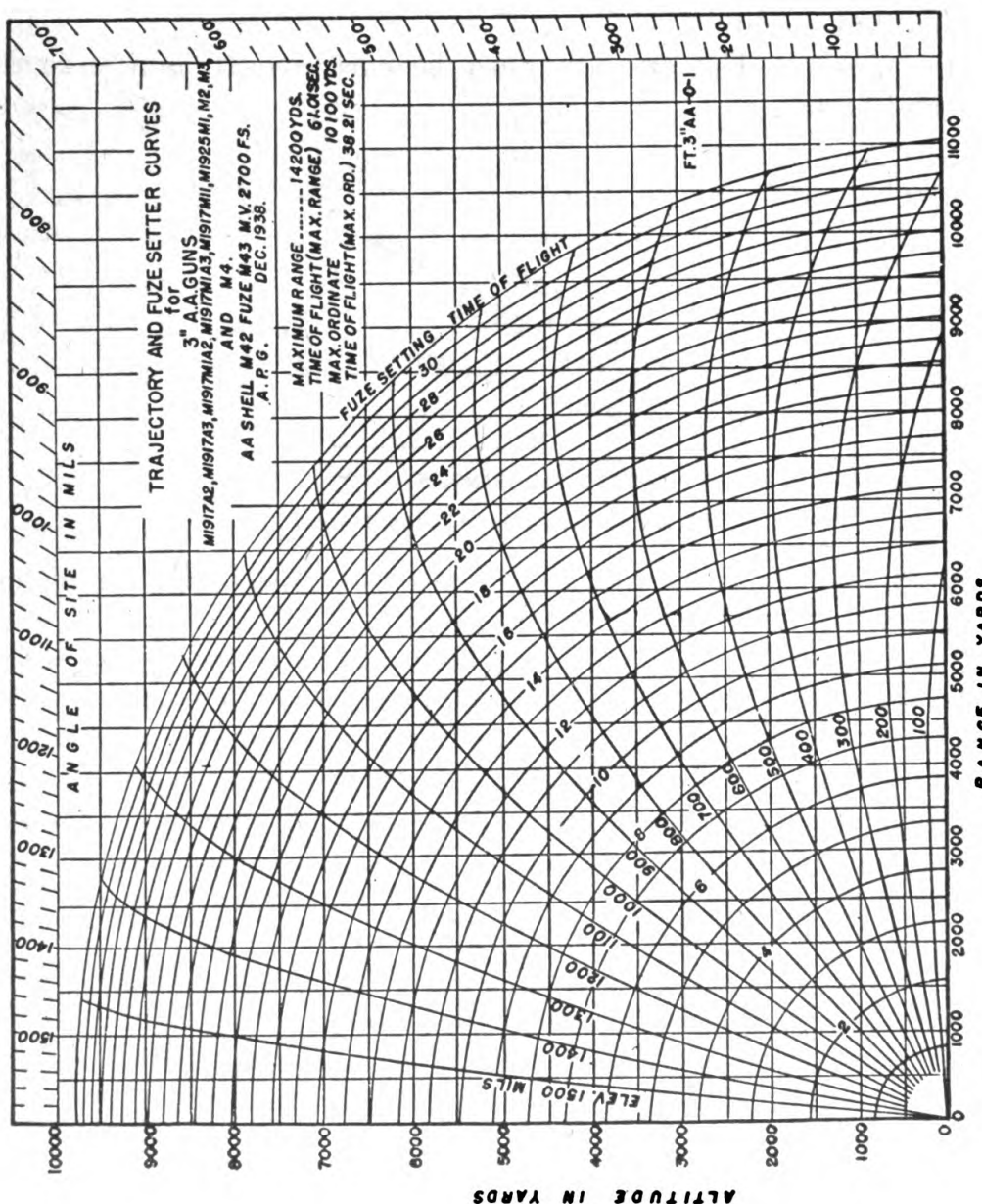


FIGURE 90.—Trajectory chart 3 AA-O-1.

**Q.** What data can be taken from a trajectory chart?—**A.** For a particular point in space the following data can be taken from the chart:

- (1) Altitude.
- (2) Horizontal range.

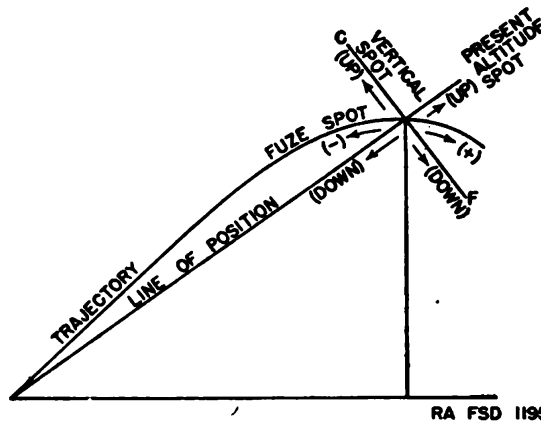


FIGURE 91.—Effect of trial fire and spot corrections.

- (3) Slant range.
- (4) Angular height.
- (5) Quadrant elevation.
- (6) Time of flight.
- (7) Fuze range.

**Q.** Given an altitude of 4,000 yards and a horizontal range of 5,000 yards, determine the other values listed above. **A.**—

- (1) Slant range equals 6,410 yards.

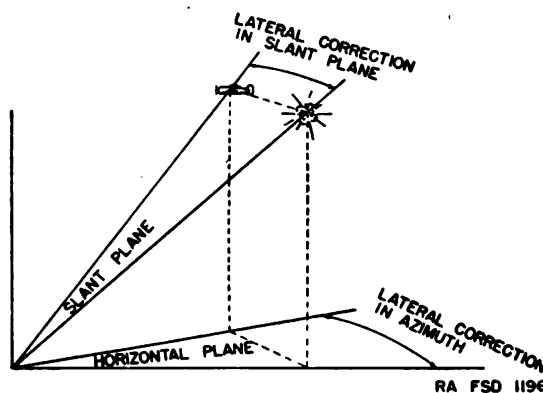


FIGURE 92.—Lateral corrections.

- (2) Angular height equals 688 mils.
- (3) Quadrant elevation equals 767 mils.
- (4) Fuze range and time of flight equals 12.7 seconds.

**106. Computation of corrections based on trial shot firings.**—**Q.** What two methods are used in observing trial shots?—**A.** The bilateral and the unilateral methods.

Q. Which method is considered the more satisfactory?—A. The bilateral method.

Q. Using the bilateral method, what data must be determined for use at the distant stations?—A. The azimuth and angular height of the trial shot point from that station.

Q. What instrument is used to determine these data?—A. The M1 (Crichlow) slide rule.

Q. Where are the data for setting the observation instrument at the guns obtained?—A. The angular height is taken from the firing table. The azimuth is the azimuth of the TSP, selected by the battery commander or range officer.

Q. Using the bilateral method, how are the deviations reported?—A. In mils right or left from the battery, above or below from the battery, and over or short from the distant station.

Q. Are the deviations of each shot used in determining the corrections?—A. They are used only in determining the deviation of the center of burst of the group, and the deviations of the center of burst are used to determine corrections.

Q. How are the deviations of the center of burst from the trial shot point used?—A. The center of burst is plotted on a trial shot chart, and the deviations from the trial shot point are measured. Measurement of these deviations indicates the amount of correction in basic data necessary to put the center of burst on the trial shot point.

**107. Effect on flight of projectile of nonstandard conditions.**—Q. What are the effects on altitude and angular height of the following nonstandard conditions?

- (1) Decrease in muzzle velocity.
- (2) Increase in density.
- (3) Rear wind.

A. The effects are—

- (1) Decreases altitude and angular height.
- (2) Decreases altitude and angular height.
- (3) Increases altitude and decreases angular height.

Q. Where is the information as to nonstandard conditions obtained?—A. Information as to ballistic density and the speed and direction of the ballistic wind is obtained from the meteorological message. Information as to muzzle velocity is obtained from previous firings. Information as to powder temperature is obtained by measurement with a thermometer.

Q. How is this information used?—A. The information is taken as a factor to enter the differential effects section of the proper

firing tables. From these tables the deviation in altitude, horizontal range, and in angular height from the point of expected burst under standard conditions can be determined.

*Q.* Wind effect on a projectile depends upon what?—*A.* Upon the direction and velocity of the wind, the direction of the plane of fire, and the time of flight.

*Q.* What is done with the ballistic wind shown in the meteorological message to make it usable?—*A.* The wind is resolved into its two components, one being in the plane of fire and the other perpendicular thereto.

*Q.* What is the effect of the range component of the wind?—*A.* To cause the burst to occur somewhere along the differential effect line for wind, thus changing the altitude, horizontal range, and angular height of the expected burst.

*Q.* What is the effect of the deflection component of the wind?—*A.* The deflection component of the wind causes a deviation of the projectile from its standard trajectory in direction (azimuth). The angular deviation will be proportional to the velocity of the deflection component, time of flight of the projectile, and quadrant elevation at which the projectile leaves the gun. Differential effect tables for cross wind will be found in the firing tables as in the case of the range wind component.

#### **108. Purpose of trial, verification, and calibration firings.—**

*Q.* Why are trial shots fired?—*A.* To determine the corrections to be applied in order to cause the projectile to burst on the trial shot point (or point in space), to allow for nonstandard conditions.

*Q.* What is the purpose of verification fire?—*A.* To show errors in orientation, errors in synchronism, large calibration errors, general functioning of the whole position-finding system, and to show that trial fire corrections have been applied properly.

*Q.* What is the purpose of calibration firing?—*A.* It is to determine the corrections to cause all guns to shoot parallel, in azimuth, angular height, and fuze range.

*Q.* Can any of these types of fire be used as a substitute for any other type?—*A.* No. Each is for a particular purpose and should be used for this purpose only.

*Q.* What is the general name applying to these three types of fire?—*A.* Preparatory fire.

*Q.* With adequate and efficient preparation of fire and preparatory fire, what results are expected?—*A.* Fire for effect, which is accurate immediately and without adjustment.

## SECTION III

## RECORDS AND REPORTS; ANALYSIS OF TARGET PRACTICE

Paragraph

Preparation of records and reports; analysis of target practice----- 109

**109. Preparation of records and reports; analysis of target practice.—Q.** What records must be kept during the firing of a target practice? **A.—**

- (1) Altitude and angular height of target record.
- (2) Battery lateral deviation record.
- (3) Battery vertical deviation record.
- (4) Flank lateral deviation record.
- (5) Timekeeper's record.
- (6) Battery azimuth record.
- (7) Flank azimuth record.
- (8) Trail shot record.
- (9) Camera deviation records.
- (10) Spotting record.
- (11) Fuze range record.
- (12) Ammunition expenditure record.

**Q.** Which of these records are kept by personnel of the firing battery?—**A.** Personnel from the firing battery must keep records (8), (10), and (12).

**Q.** What is the purpose of analysis of target practice?—**A.** To determine the proficiency in firing of an organization, to compare its proficiency with that of other organizations, and to obtain information for research.

**Q.** What elements of data are necessary for an accurate analysis of antiaircraft target practice?—**A.** The lateral and vertical deviations of the bursts as seen from the battery; the over or short deviations for range as seen from the flank station; the position of the target with respect to the battery in both the horizontal and vertical planes; and the time of bursts with respect to time zero for each course.

**Q.** How are these elements obtained?—**A.** Two theodolite cameras set up at the ends of an accurately surveyed base line furnish all the necessary data.

**Q.** How are lateral and vertical deviations obtained?—**A.** Deviations are photographed in mils deviation from the target on the battery camera film.

**Q.** How are range deviations obtained?—**A.** Deviations are photographed in mils from the target on the flank camera film.

*Q.* What is a mil?—*A.* A mil is one sixty-four hundredths part of a circle, or approximately the angle subtended by 1 yard at 1,000 yards.

*Q.* What is the plane of position?—*A.* The plane through the observer which includes the target and is perpendicular to the horizontal plane.

*Q.* In which plane is azimuth measured?—*A.* Azimuth is measured in the horizontal plane in mils clockwise from north.

*Q.* In which plane is angular height measured?—*A.* In the vertical plane.

*Q.* Explain the use of each target practice form used in your battery.—*A.* -----

*Q.* Who is responsible for the installation of the cameras?—*A.* The records section is responsible for the installation and operation of the cameras.

*Q.* Who surveys the positions for camera base-end stations?—*A.* Normally the regimental master gunner, otherwise the records section.

*Q.* Who installs and maintains the records section communications?—*A.* The records section is responsible for the installation and maintenance of its own lines.

*Q.* What is the main function of the records section?—*A.* The records section is a peacetime set-up solely for the purpose of taking complete, accurate, unbiased records of the target practices of the gun, machine-gun, and searchlight batteries.

*Q.* What records are required for gun target practices?—*A.* Camera records, supplemented by visual target position and spotting records of each course fired on.

*Q.* What records are kept by the camera section for gun practices?—*A.* The only record kept by this section is the camera operator's report showing battery firing, date, direction of course, counters at start and finish, rounds fired, amount of film used, and aperture setting.

*Q.* What records are kept by the visual section for gun practices?—*A.* W. D., C. A. C. Form No. AA-8 (Target Position or Adjustment Record) for each section (azimuth and elevation); W. D., C. A. C. Form No. AA-9 (Deviations or Spotter's Record) for lateral, vertical, and range deviations; record of time of burst of each shot and elapsed time from "Commence firing" to last discharge.

*Q.* Who coordinates the camera and visual records?—*A.* The officer in charge of records.

*Q.* What records is the records section responsible for in the detection phase of gun practices?—*A.* The records section takes visual target position records of the target at 5-second intervals, using BC telescopes at the ends of a surveyed base line about 3,000 yards long.

In addition, a record is kept of the time from target reported until chief umpire reports "On target."

*Q.* What records are turned over to the gun battery for the detection phase?—*A.* Form No. AA-8 for stations  $O_1$  and  $O_2$ , W. D., C. A. C. Form No. AA-10 (Chief Timekeeper's Record (Guns or Machine Guns)), and W. D., C. A. C. Form No. AA-4a (Target Position Report).

*Q.* Where are the data obtained to complete Form No. AA-4a?—*A.* From the copies of Form No. AA-8.

*Q.* What means are used to obtain such required elements of data as horizontal range, slant range, and altitude?—*A.* These elements may be obtained by plotting or by means of a M1 (Crichlow) slide rule.

*Q.* If the flank ( $O_2$ ) station does not get on target, how is the course of the target plotted to obtain data for Form No. AA-4a?—*A.* Using the angular height from the  $O_1$  BC telescope and the altitude as read from the height finder, the horizontal range is determined for each 5 seconds, either graphically or with the M1 slide rule. Using the computed horizontal range and the observed azimuth from the BC telescope, the course of the target can be plotted.

*Q.* What reports are completed by the records section for the firing phase of gun practices?—*A.* The records section completes W. D., C. A. C. Form No. AA-18 (Battery (Flank) Camera Report), Form No. AA-4a, and W. D., C. A. C. Form No. AA-11 (Computation of Impacts).

*Q.* Which records form the most accurate basis for the analysis?—*A.* The camera records since they are more accurate than the visual records. Regulations prescribe the use of camera records when available.

*Q.* Who is responsible for the location of base-end stations?—*A.* The records section.

*Q.* Who installs the communications for the visual section?—*A.* Records section personnel install and maintain their own communication system.

*Q.* Where are BC telescopes located with respect to the cameras?—*A.* As close to the cameras as possible without interfering with line of sight from either instrument.

## CHAPTER 7

## DATA TRANSMISSION SYSTEMS FOR GUNS

|                                  | Paragraph |
|----------------------------------|-----------|
| Data transmission system M4..... | 110       |
| Data transmission system M3..... | 111       |
| Power plant.....                 | 112       |
| Care and maintenance.....        | 113       |

**110. Data transmission system M4.—Q.** What does the system include?—**A.** An a-c power source, induction type transmitters and receivers, connecting cables, gun receptacle boxes, gun distribution boxes, and main and gun junction boxes.

**Q.** What data are transmitted?—**A.** Altitude from the height finder to the director; present azimuth and present angular height from the director to the height finder; and firing azimuth, quadrant elevation, and fuze range from the director to the guns.

**Q.** How many units are there in a director?—**A.** Five transmitter units, one each for firing azimuth, quadrant elevation, fuze range, present azimuth, and present angular height; and one receiver unit for altitude.

**Q.** How many motors are there in each unit?—**A.** The firing azimuth and quadrant elevation transmitting units have two motors geared together at a ratio of 16 to 1. The other transmitting units and the receiving unit each have one motor.

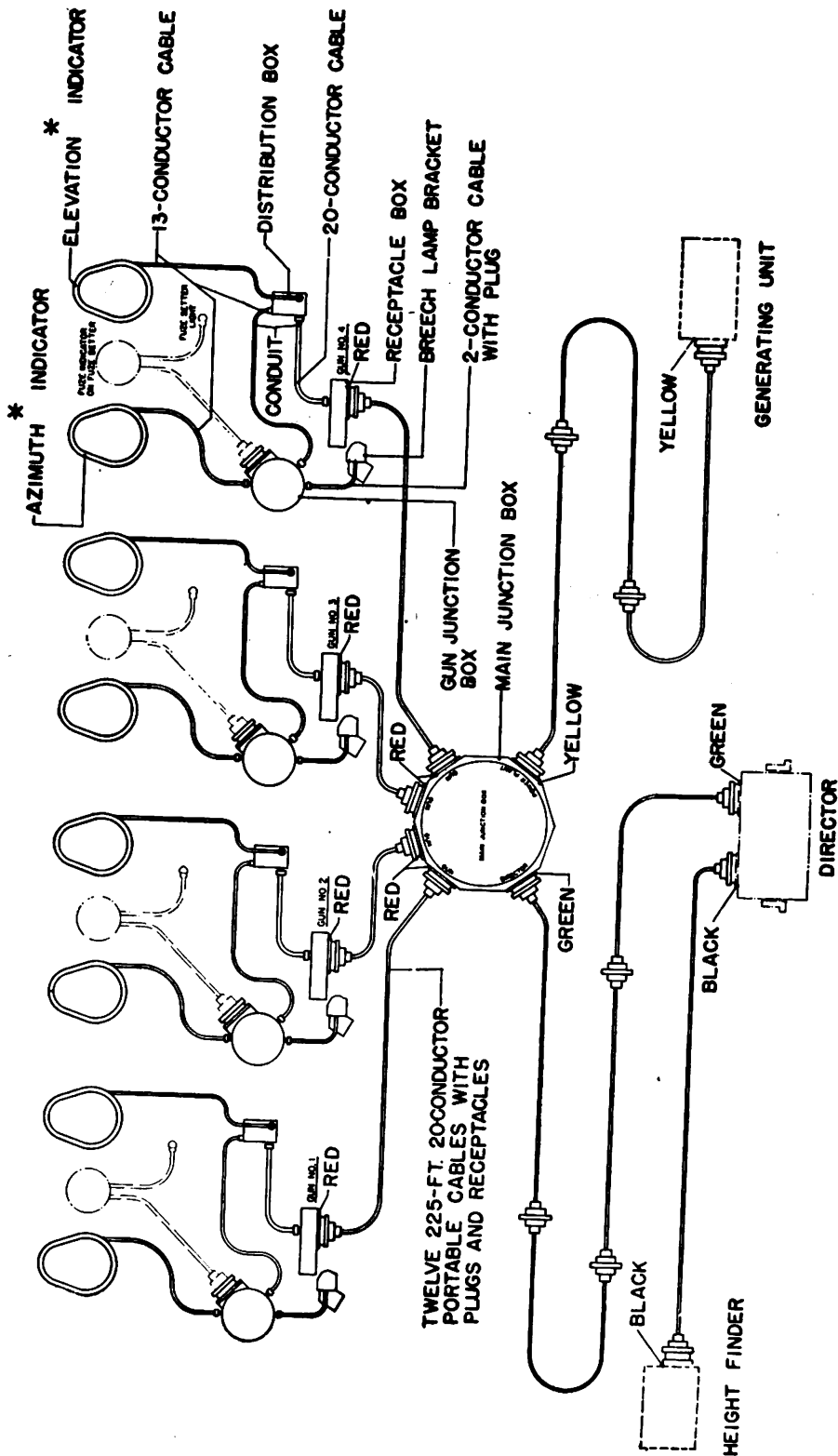
**Q.** What apparatus is necessary for each set of data to be transmitted?—**A.** An induction type transmitter, one or more repeaters, and a source of power.

**Q.** What power is used for the fields?—**A.** 110–120 volts, 60-cycle, single-phase alternating current.

**Q.** How are the rotors wound?—**A.** Transmitter and repeater rotors have three sets of windings, each brought out to a slip ring.

**Q.** Explain the connections between transmitter and repeater.—**A.** The fields are connected together in parallel and both energized from the same source. The three slip rings of the transmitter are connected to the corresponding slip ring of one or more repeaters.

**Q.** Why does the repeater rotor follow the transmitter?—**A.** When the transmitter rotor and repeater rotor are in the same position with respect to their fields there is no torque or turning force, but when the transmitter is turned to a new position currents are induced in the transmitter rotor windings and in turn flow through to the repeater

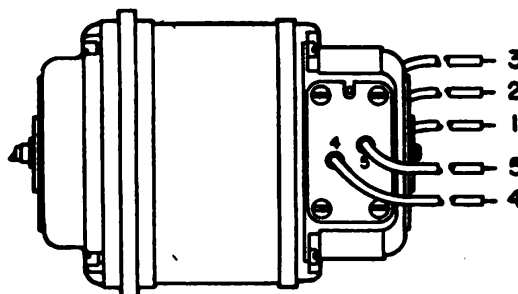


**\* AZIMUTH AND ELEVATION INDICATORS ARE ALIKE**

**FIGURE 93.—Data transmission system M4.**

windings. These currents react with the field and bring the repeater rotors to the same position, or the position of zero current.

**Q.** What is the purpose of synchronizing the system?—**A.** To insure that all repeaters are connected to the proper transmitters, that repeater motors rotate in the proper direction, and that the readings of the transmitter and repeater dials correspond exactly at all times.



RA FSD 1226

FIGURE 94.—A-c synchronous transmitter or repeater.

**Q.** When is it necessary to synchronize the system? **A.**—

- (1) When a new system is installed.
- (2) When one or more transmitters or repeaters are replaced.
- (3) For verification purposes at short intervals.

**Q.** How is the direction of rotation of any repeater reversed?—**A.** By exchanging any two of its rotor leads.

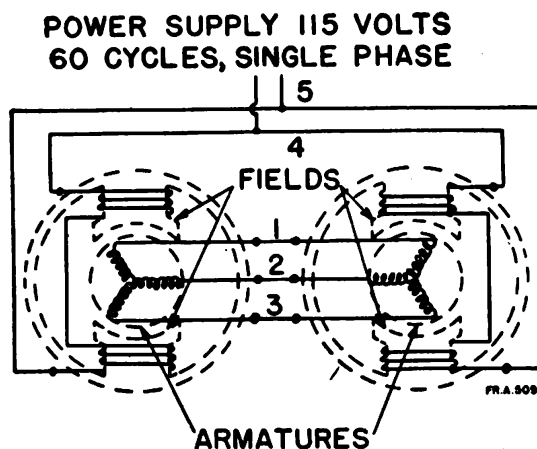


FIGURE 95.—Schematic diagram, a-c synchronous transmitter and repeater.

**Q.** What is the trouble if a repeater pointer goes the wrong way?—**A.** Two of its rotor leads have been interchanged.

**Q.** How is the direction of all azimuth receivers reversed?—**A.** By exchanging at the main junction box any two rotor leads from the azimuth transmitter.

**Q.** After all receivers are properly connected and direction of rotation is verified, how are all dials synchronized, that is, made to agree exactly with the transmitter? **A.**—

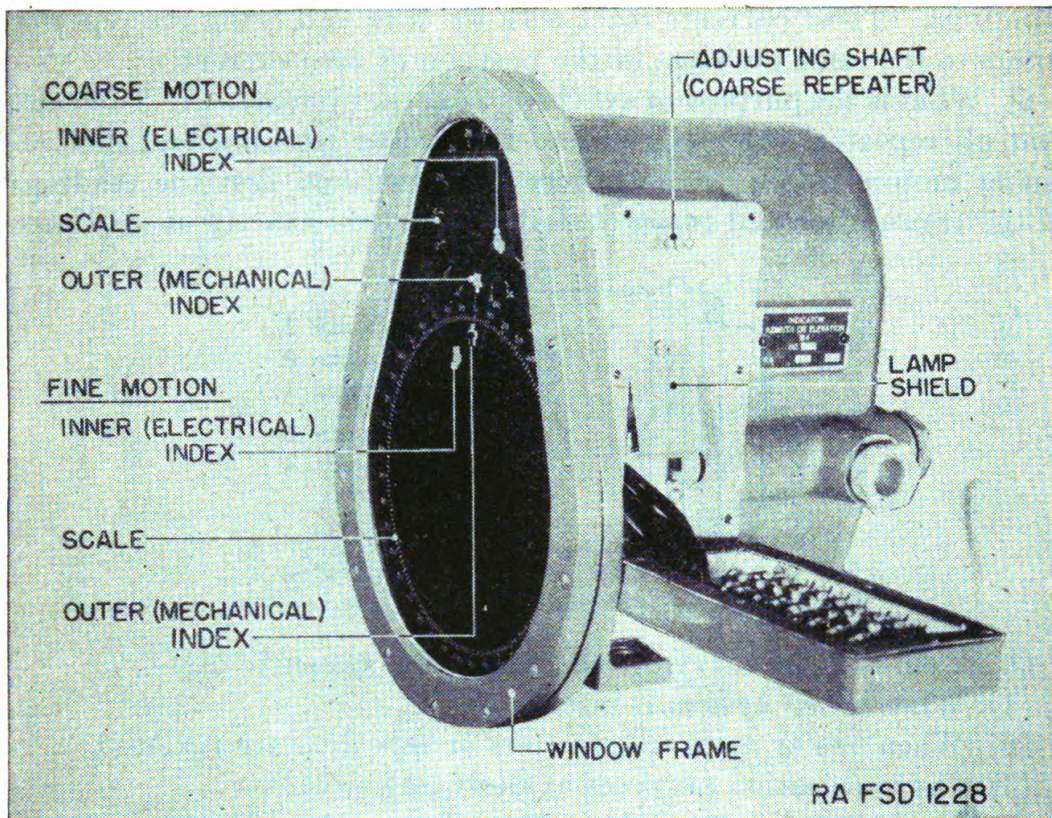


FIGURE 96.—Azimuth or elevation indicator M4, right-hand cover open.

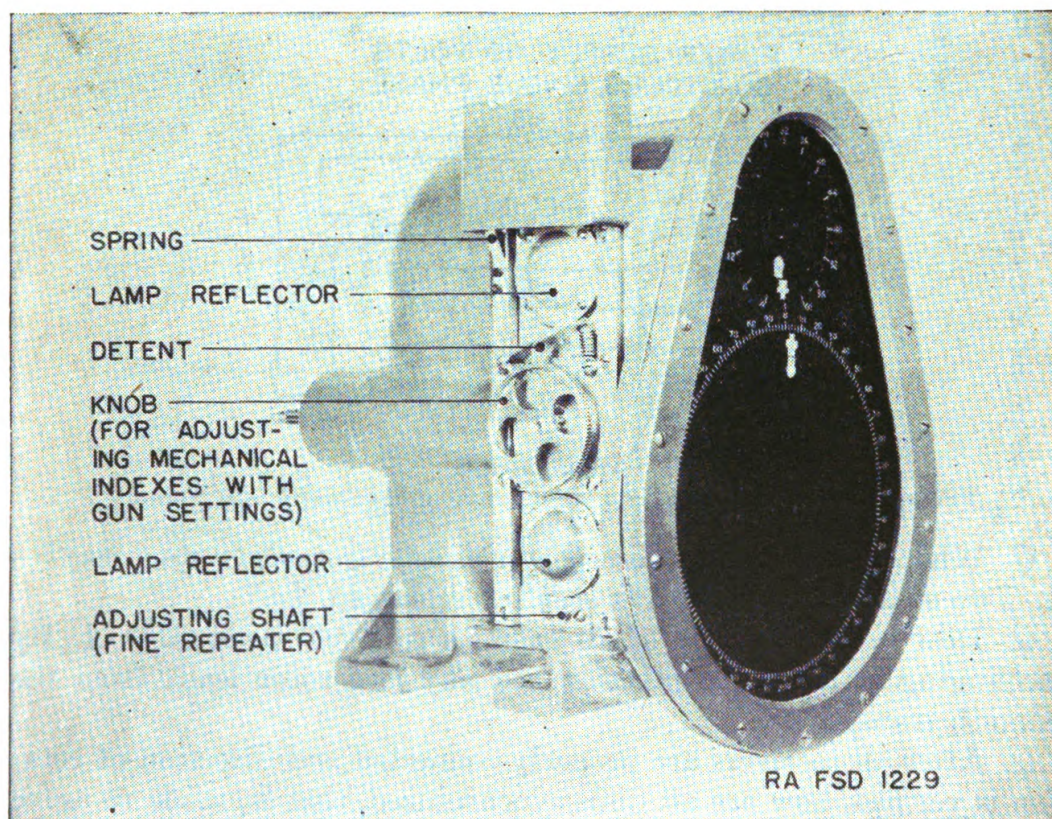


FIGURE 97.—Azimuth or elevation indicator M4, left-hand cover raised.

(1) *Azimuth and elevation.*—The fine or lower dial is synchronized by raising the sliding cover on the left side and adjusting, with a screw driver, the slotted shaft end which protrudes into the lower part of the cavity. The coarse or upper dial is synchronized by lowering the cover plate on the right side of the indicator and turning a similar shaft which protrudes into the upper part of the cavity enclosing the terminal board. Care must be exercised when lowering this cover to avoid damaging the gasket and conductors.

(2) *Fuze range.*—The repeater case may be rotated to synchronize the indicator with the data transmitter in the director by unscrewing

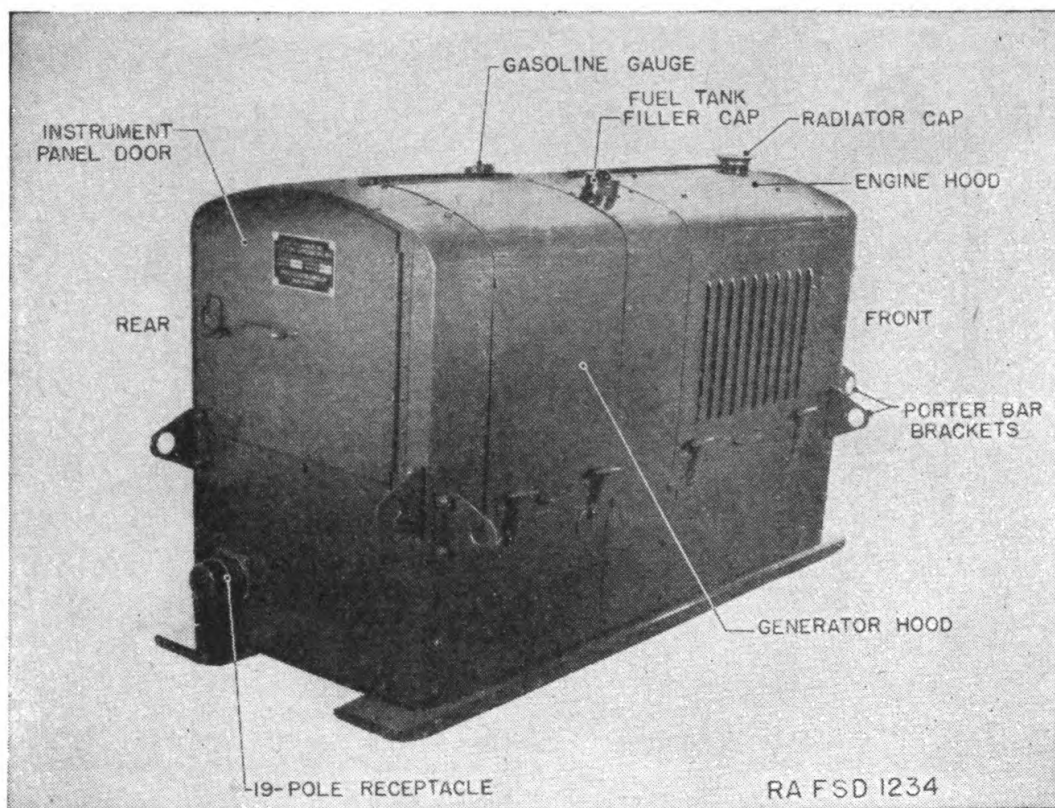


FIGURE 98.—Gasoline-electric a-c generating unit M4.

the cover on the right side of the indicator and adjusting the slotted shaft end which protrudes into the upper part of the cavity.

**111. Data transmission system M3.**—In general, the same questions apply for this data transmission system as for the M4 system.

*Q.* With what directors is the M3 data transmission system used?—

*A.* The M3 (3-inch guns) and the M3A1 (105-mm guns) and with the M4.

*Q.* Does this system employ single- or double-unit transmitters and receivers in the transmission of azimuth and elevation?—*A.* Double-unit transmitters and receivers.

*Q.* What is the gear ratio between the fine and coarse pointers?—  
*A.* Sixteen to one.

*Q.* How many mils does one complete revolution of the fine pointer represent?—*A.* Four hundred.

**112. Power plant.**—*Q.* What are the principal items in the gasoline-electric a-c generating unit M4?—*A.* The engine, the generator, and the instrument panel.

*Q.* How many such units are furnished with each data transmission system and why?—*A.* Two. There is no battery power supply as with the M3 system, and one generating unit must always be available

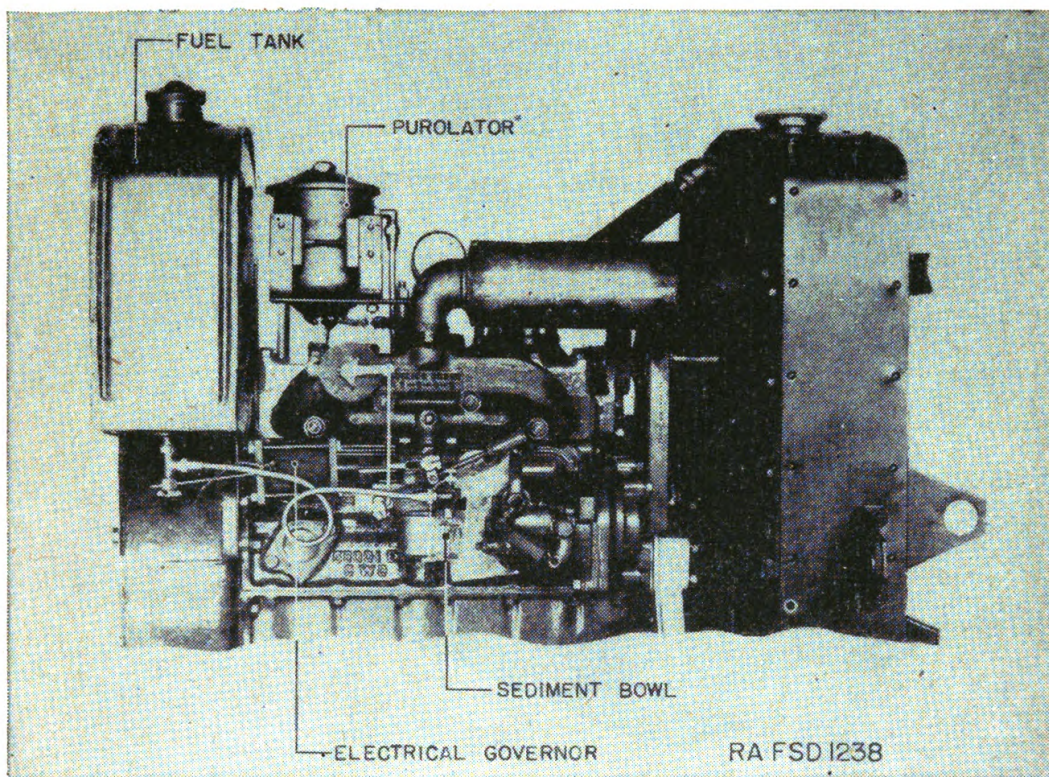


FIGURE 99.—Gasoline engine, right side.

to supply power to the system. Serial Nos. 1 to 87 have a Briggs oil clarifier as shown; serial Nos. 88 to 275 have a Purolator oil filter.

*Q.* Describe the engine briefly. *A.*—

(1) The engine is a 10-horsepower, four-cylinder, water-cooled gasoline engine.

(2) Lubrication is force-fed by a pump to all connecting rods and main bearings. Oil pressure is indicated by a pressure gage and the oil level by a bayonet (dip-stick) type gage.

(3) A thermostatic device controls the opening of the choke valve, the choking action thus depending on the engine temperature.

(4) To maintain the proper speed, the engine is provided with a mechanical governor.

(5) The fuel supply system has a shut-off cock, a float-type gage, a filter, and a sediment trap. The intake air is filtered by an air cleaner.

(6) The engine has an electric starting motor, operating from a 6-volt storage battery which is maintained in charged condition by a charging generator.

(7) Most of the parts employed in these engines are of standard automotive design.

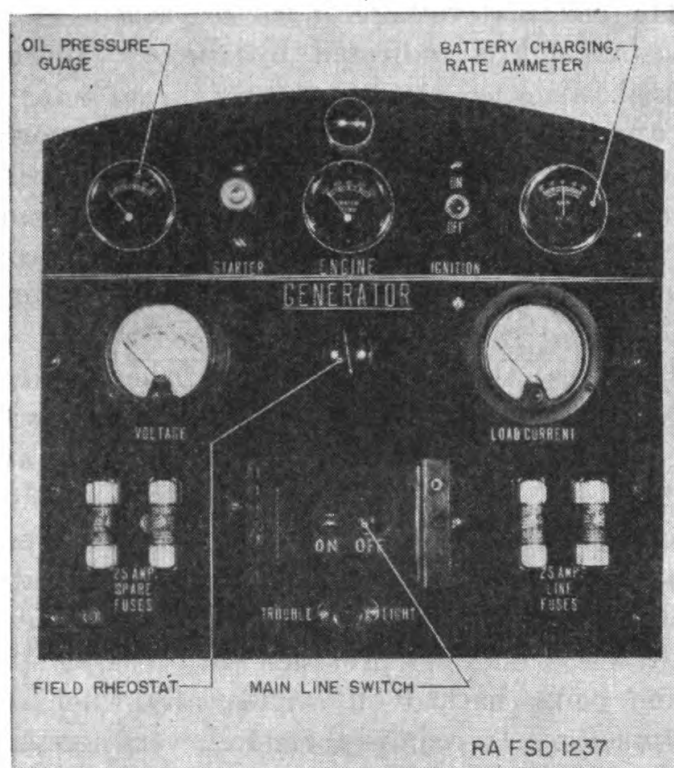


FIGURE 100.—Instrument panel.

(8) On units, serial Nos. 88 to 275, inclusive, an electrical governor is also provided to supplement the action of the mechanical governor. Serial Nos. 88 to 275, inclusive, have a Purolator oil filter as shown; lower serial numbers have a Briggs oil clarifier.

*Q.* Describe the generator briefly.—*A.* The generator is a 2½-kva, 125-volt, 60-cycle, single-phase alternator which is coupled directly to the gasoline engine. It should operate at 60 cycles with normal engine speed of 1,200 rpm.

*Q.* Describe the instrument panel briefly.—*A.* This panel contains the various meters, switches, fuses, and other equipment necessary for the protection and operation of the generating unit.

(1) Mounted on the rear of the instrument panel are means for exciting the transmitters and repeaters at reduced voltage when power is applied, while the latter are stabilized at their synchronized positions. Units, serial Nos. 1 to 87, inclusive, use a line resistor shunted by the contacts of an auxiliary relay under control of a time delay relay in which passage of an inert gas through an orifice determines the timing interval (Agastat relay); units Nos. 88 to 275, inclusive, use a field resistor shunted by a relay using a synchronous motor timing element (Cramer relay).

(2) A tapped resistor mounted back of the panel provides a means for equalizing the terminal voltage at the director and the gun data indicators. The terminal voltage of the alternator is controlled by the field rheostat and is indicated by the a-c voltmeter on the instrument panel.

**113. Care and maintenance.—Q.** Give four important items to consider in the care of plugs and receptacles. **A.—**

(1) When not in use, the receptacles on the boxes and the plugs on the ends of the cables should be closed and have their covers screwed up tight to protect their interior parts from injury and to render them watertight.

(2) When not in use, the plug on the end of the fuse indicator cable should be kept connected to the dummy receptacle, with the cable carefully coiled about the instrument, and the collar screwed up tight to make it watertight.

(3) When disconnecting the plugs and receptacles, grasp the bodies to pull them apart, and carefully avoid pulling on the cable or spring.

(4) The rear gland followers on the cable plugs should be screwed up tight at all times. They are provided with locking springs to prevent them from being backed off accidentally when disconnecting plugs and receptacles. To remove these followers necessitates the use of considerable force which may occasionally damage the spring. Therefore, no attempt should be made to remove them unless it is necessary to repair the plug or cable. Short and jerky rotation of these followers in a counterclockwise direction will allow them to be removed with comparatively little effort.

(5) Do not allow dirt of any kind to accumulate in the plugs or receptacles, as this would impair the connection accomplished by them. When the cables are not connected, all plugs and receptacles should be kept closed with the covers provided so as to exclude moisture from these units.

**Q.** What precautions must be followed in handling cable? **A.—**

(1) Avoid bending the cable on a short radius, or allowing it to chafe against any moving object.

(2) Oil and grease are detrimental to rubber of any kind and care should therefore be exercised to see that the cables are kept free of these materials.

(3) Store cables in a cool, dark place, as heat and sunlight cause rapid deterioration of rubber products.

(4) In case it is necessary to tape the end of any of the latex conductors of the 20-conductor flexible cable, do not use friction tape. Apply rubber tape only, as the solvent in the saturated cloth of friction tape will in time dissolve the latex insulation.

**Q.** How is cable tested for continuity and shorts? **A.**—

(1) Remove the cable from the system and connect one side of a battery or other power source to conductor No. 1 at one end of the cable.

(2) Connect one terminal of a suitable voltmeter to the other side of the battery or power source and connect, one at a time, each of the conductors of the cable (at the opposite end) to the second terminal of the voltmeter.

(3) If the given conductor (No. 1) is in good condition, the voltmeter will indicate the battery or power source voltage when, and only when, the No. 1 conductor is connected; in all other cases the voltage should read zero.

(4) If full voltage is not indicated when the No. 1 conductor (at the opposite end) is touched, the conductor is broken.

(5) If a voltage is indicated when any other conductor is touched, that conductor is shorted to No. 1.

(6) Each conductor should be tested in turn in the same way.

**Q.** Where may the cable from the generating unit be plugged?—**A.** Only into the receptacle on the main junction box which is painted yellow and marked "power plant."

**Q.** Where is detailed information on the operation and maintenance of data transmission systems found?—**A.** In the "Notes on Matériel" accompanying the system.

## CHAPTER 8

## AUTOMATIC WEAPONS

|   | Paragraphs |
|---|------------|
| SECTION I. Machine guns.....                    | 114-121    |
| II. 37-mm guns.....                             | 122-125    |
| III. Duties of members of squad or section..... | 126        |
| IV. Selection of position and emplacement.....  | 127-128    |
| V. Preparation for service practice.....        | 129-131    |

## SECTION I

## MACHINE GUNS

|   | Paragraph |
|---|-----------|
| Caliber .30 machine gun.....              | 114       |
| Caliber .50 machine gun.....              | 115       |
| Machine-gun mount.....                    | 116       |
| Care and cleaning of machine guns.....    | 117       |
| Packing barrel of machine gun.....        | 118       |
| Head space adjustment of machine gun..... | 119       |
| Malfunctioning of machine gun.....        | 120       |
| Replacement of parts.....                 | 121       |

114. Caliber .30 machine gun.—Q. Describe the action of the firing mechanism when the gun is fired.—A. The rear end of the trig-

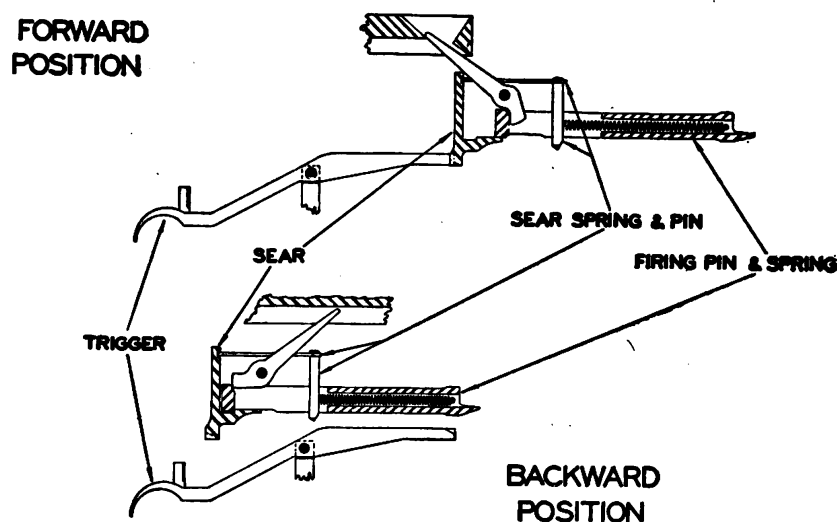


FIGURE 101.—Firing mechanism, Browning caliber .30 machine gun.

ger is pressed upward, causing the front end to be depressed. The beveled surface catches on the beveled surface of the sear and pulls it down, releasing the shoulder at the rear end of the firing pin from the shoulder at the lower end of the sear. The firing pin drives

forward under the action of the firing-pin spring, its point striking the cartridge primer and exploding the cartridge. If the trigger is held in the firing position, the beveled surfaces of sear and trigger strike as soon as the bolt is within  $\frac{1}{16}$ -inch of closing, causing the gun to fire automatically and continuously.

**Q.** Describe the recoil of the gun. **A.**—

(1) During the first  $\frac{5}{8}$  inch of recoil, the barrel, barrel extension, and bolt move to the rear as a unit, locked together by the breech

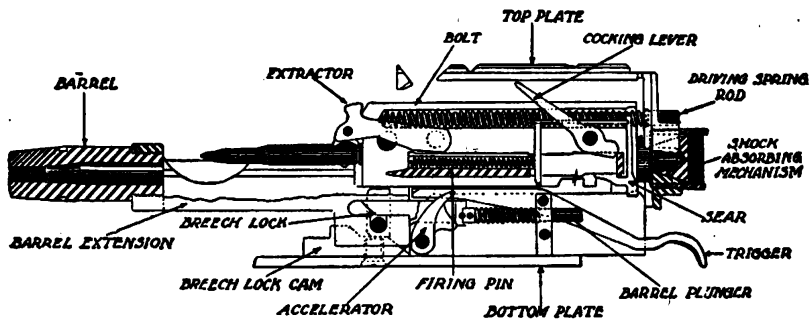


FIGURE 102.—Caliber .30 machine gun—moving parts in rear position.

lock. The breech lock then clears the top of the breech lock cam and rides down the rear slope of the cam when the projecting ends of the breech lock pin strike the ends of the lock frame arms which slope downward and to the rear. The downward movement of the breech lock releases the bolt from the barrel and barrel extension and allows the bolt to continue its recoil to the rear. As the barrel extension continues to the rear, its rear end strikes the accelerator and turns it

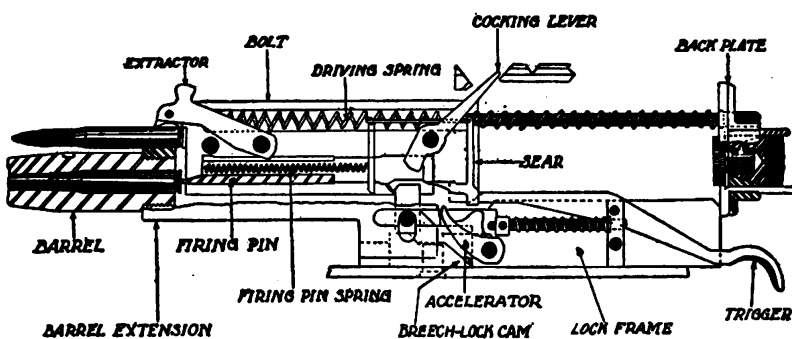


FIGURE 103.—Caliber .30 machine gun—moving parts in forward position.

backward. The claws of the accelerator catch the projections on the lower side of the bolt and flip the bolt to the rear. The stud on the rear end of the barrel extension bears against the end of the barrel plunger spring and compresses it as the barrel extension moves to the rear. The accelerator turns back until it strikes its stop, the shoulders of the barrel extension stud catching behind its claws, locking the barrel extension to the lock frame and holding the barrel

plunger spring compressed. The bolt moves to the rear under the force of recoil plus the flip given by the accelerator, compresses the driving spring, and is finally stopped by the buffer plate, the buffer disks taking up the remaining shock.

(2) As the bolt moves to the rear, the cocking lever moves with it. Its upper end is caught in the opening in the top plate, causing the lower end to rotate to the rear, pulling back the firing pin with it against the firing-pin spring until the shoulder at the rear end of the firing pin locks against the shoulder on the bottom of the sear.

(3) As the bolt recoils it also brings with it the empty cartridge case from the chamber, gripped on the T-slot, and a fresh cartridge from the belt, gripped in the extractor. The extractor cam plunger rides along the top of the extractor cam and the extractor feed cam until it is forced in by the beveled part of the extractor feed cam.

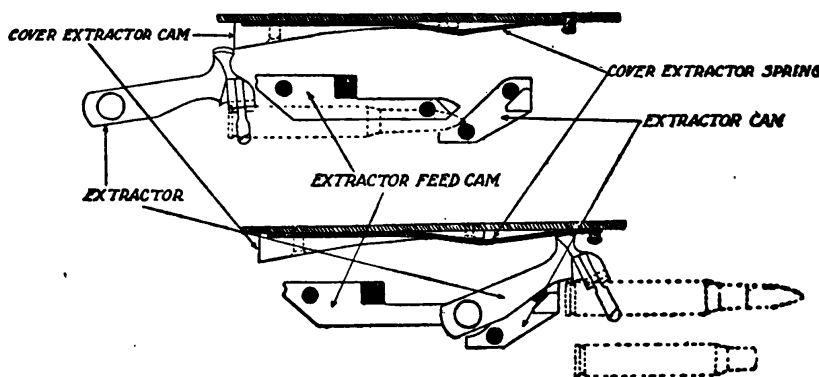


FIGURE 104.—Extracting and loading mechanism, Browning caliber .30 machine gun.

The extractor is then forced down by the cover extractor cam, and the plunger springs out behind the extractor feed cam.

*Q.* Describe the action of the gun in counterrecoil.—*A.* Counter-recoil is accomplished by the action of the driving spring on the bolt. As the bolt moves forward, the extractor is guided downward by the action of the extractor feed cam on the extractor cam plunger, forcing the unfired round down the T-slot in line with the chamber. The ejector knocks the empty cartridge from the T-slot and holds the new cartridge in line with the chamber. (The empty case may have already fallen out without the action of the ejector.) The bottom projections on the bolt strike the accelerator and turn it forward, unlocking the barrel extension from the lock frame. When the accelerator has been tripped, the barrel extension and barrel move forward, assisted by the barrel plunger spring. Part of the forward force of the bolt acts through the accelerator to push the barrel extension and barrel forward. As the barrel extension moves forward, the breech lock is forced upward by the breech lock cam and locks the breech just before the re-

coiling parts reach the firing position. (The breech lock engages in a recess cut in the bottom of the bolt and thus locks it firmly to the barrel extension and against the rear end of the barrel.) During the final forward movement of the bolt, the extractor rises as the plunger moves along the top of the extractor cam. The ejector moves outward, leaving the cartridge in the chamber gripped by the T-slot. The extractor grips the first round in the belt and is held down firmly by the cover extractor spring, ready to extract the round during the next recoil.

**Q.** Describe the action of the belt feed mechanism when the gun fires. **A.**—

(1) As the bolt moves to the rear, the belt feed lever stud, which rides in the cam groove in the top of the bolt, is forced to the right caus-

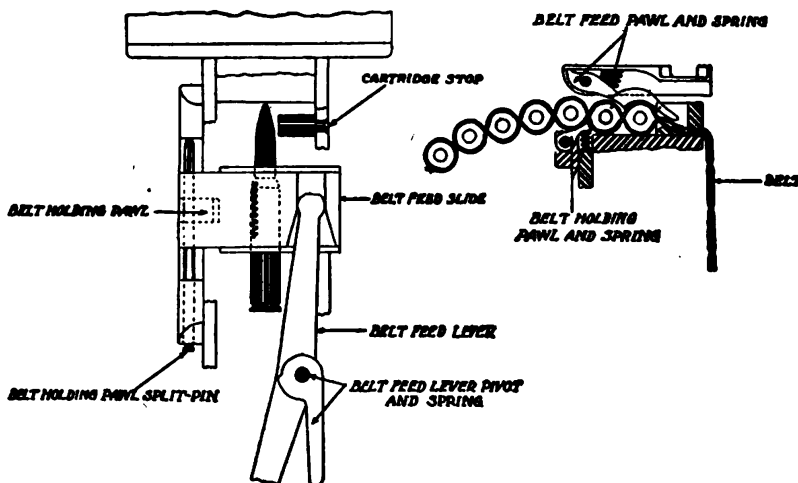


FIGURE 105.—Belt feed mechanism, Browning caliber .30 machine gun.

ing the belt feed lever to force the belt feed slide to the left. The belt feed pawl engages on the left of the first cartridge in the belt.

(2) As the bolt goes forward, the belt feed lever stud moves to the left in the cam groove and causes the belt feed lever to force the belt feed slide to the right. The belt feed pawl carries the first cartridge to the right against the cartridge stops, ready to be gripped and withdrawn from the belt by the extractor. The next cartridge is carried over the belt holding pawl, which rises behind it and holds it in position to be engaged by the belt feed pawl on its next movement to the left.

**115. Caliber .50 machine gun.**—**Q.** Describe some of the differences between the caliber .50 machine gun and the caliber .30 machine gun. **A.**—

(1) The caliber .50 gun has an oil buffer in place of the lock frame.

(2) The extractor feed cam, just back of the extractor cam, is pivoted and actuated by a spring and is called the switch in the caliber .50 gun.

(3) The caliber .50 gun has a water-circulating system for cooling the gun while the caliber .30 gun depends on the water in the water jacket to cool the gun properly.

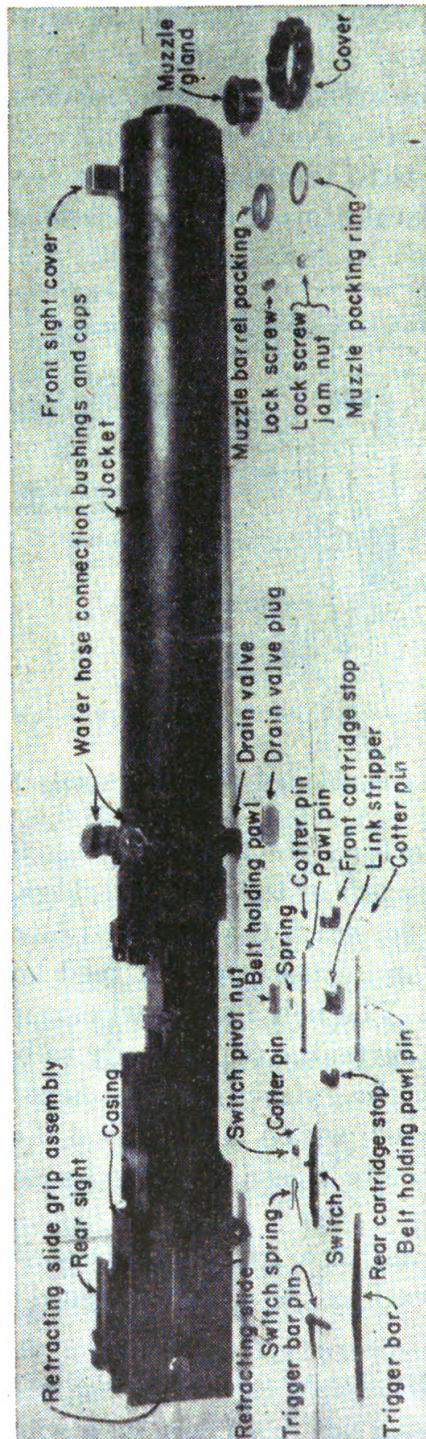


FIGURE 106.—Casing and water jacket group.

(4) The caliber .50 gun is provided with a side plate trigger to permit the gun to be fired by depressing a lever on the M2 mount. The gun may also be fired by depressing the back plate trigger.

(5) The caliber .50 gun may be assembled to fire either with right-hand or left-hand feed.

*Q.* Explain the trigger action of the caliber .50 machine gun on the first shot. *A.*—

(1) *Backplate trigger.*—When the rear end of the backplate trigger, which is pivoted in the center, is pressed down, its forward end pushes up the rear end of the trigger bar. This in turn causes the front end

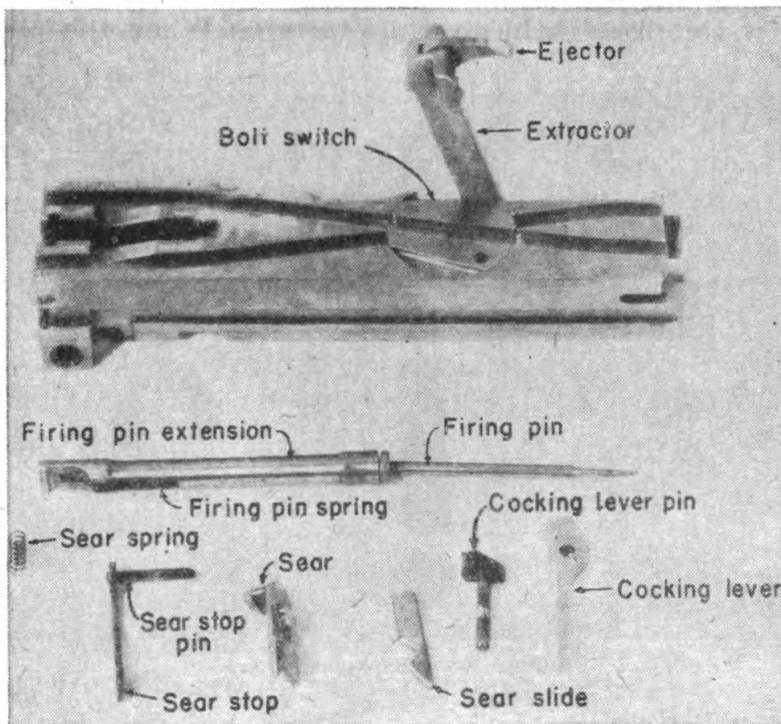


FIGURE 107.—Bolt group.

of the trigger bar to press down on the top of the sear, forcing the sear down until the sear notch is released from the shoulder of the firing pin. The firing-pin spring forces the firing pin forward to fire the cartridge.

(2) *Side plate trigger.*—When the trigger lever on the back rest of the M2 mount is depressed, the linkage pulls the slide of the mechanism to the rear. A lug on the slide engages a lug on the side plate trigger of the gun, causing this also to be pulled to the rear. The side plate trigger cam pushes the firing stud inward. This in turn forces the sear slide in the rear face of the bolt to the right, thus forcing the sear down. The remainder of the action is the same as was described for the backplate trigger.

Q. Describe the recoil of the caliber .50 gun. A.—

(1) The explosion of the cartridge forces the recoiling parts (barrel, barrel extension, and bolt) backward, locked together by the breech lock. When they have recoiled about  $1\frac{1}{8}$  inches, the breech lock pin strikes the cam surface of the breech lock depressors. This unlocks the bolt from the barrel extension and permits the bolt to continue to the rear. The barrel extension strikes the accelerator, turning it backward, and continues to the rear until its shank engages behind the claws of the accelerator, locking the barrel extension to the oil buffer body. As the accelerator turns backward it strikes the bottom projection on the bolt and accelerates it to the rear. As the bolt moves backward it compresses the driving spring. When the rear end of

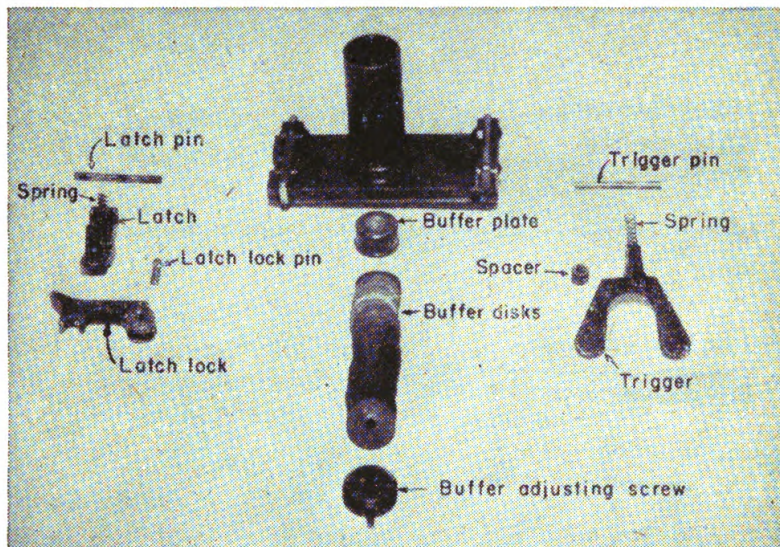


FIGURE 108.—Backplate group.

the bolt strikes the buffer plug in the backplate, its remaining force is absorbed in the fiber buffer disks.

(2) In its rearward movement, the bolt brings with it a cartridge from the belt gripped by the extractor and an empty case from the chamber gripped in the T-slot. The cam lug on the extractor rides along on top of the switch until near the end of the backward movement of the bolt. Then the extractor is forced downward by the cover extractor cam until its cam lug is below the switch.

(3) As the bolt moves backward, the upper end of the cocking lever is forced forward by the top plate bracket, which brings the lower end to the rear. The lower end of the cocking lever brings with it the firing pin, compressing the firing-pin spring against the sear stop pin. The shoulder of the firing pin engages in the notch in the sear under pressure of the sear spring.

Q. Describe the action of the caliber .50 machine gun in counter-recoil. A.—

(1) The driving spring forces the bolt forward. The lug on the lower rear end of the bolt strikes the accelerator and turns it forward. This unlocks the barrel extension from the oil buffer body. The barrel extension remains linked with the oil buffer piston rod. When the accelerator has been tripped, the barrel extension and barrel move forward, assisted by the oil buffer spring. Part of the forward force of the bolt, acting through the accelerator, also assists in the forward movement of the barrel and barrel extension. The breech lock is forced upward by the breech lock cam and locks the breech just before the recoiling parts reach the firing position. (The breech lock engages in a recess cut in the bottom of the bolt and thus locks it firmly to the barrel extension and against the rear end of the barrel.)

(2) When the bolt starts forward, the cam lug on the extractor, riding under the switch, rotates the extractor downward. This causes the extractor to force the new round down the T-slot in line with the chamber. The ejector knocks the empty case from the T-slot and holds the new cartridge in line with the chamber. (The empty case may have already fallen out without the action of the ejector.) As the bolt continues forward, the extractor rises as its cam lug moves along the top of the extractor cam, and the ejector moves outward, leaving the cartridge in the chamber gripped by the T-slot. The extractor grips the first cartridge in the belt and is held down firmly by the cover extractor spring, ready to extract the cartridge.

(3) During the forward movement of the bolt, the upper end of the cocking lever is forced backward and the lower end moves forward away from the rear of the firing pin.

Q. Describe the action of the belt feed mechanism.—A. The belt feed mechanism operates in the same manner as that of the caliber .30 machine gun.

Q. What is the action of the trigger in automatic fire?—A. If the trigger is held down, as the bolt moves forward the cam on the end of the trigger bar engages the top of the sear (backplate trigger) or the firing stud engages the sear slide (side plate trigger), releasing the firing pin. The gun thus fires automatically, repeating the operations already described. (The release of the firing pin actually takes place when the recoiling parts are still about  $\frac{1}{8}$  inch from the forward position but after the breech is locked.)

Q. Describe the oil buffer and its action.—A. The forward end of the oil buffer group has breech lock depressors the same as are found on the lock frame of the caliber .30 gun. The oil buffer body is locked in position in the gun by the oil buffer spring lock which

fits into a recess in the right-hand side plate. The rear end of the oil buffer body bears against the backplate. The oil buffer tube assembly is held in position in the body by the tube lock spring. Inside the tube is a valve and a piston. The piston is connected directly to the barrel extension by the piston rod. When the barrel extension recoils before the breech is unlocked it drives the piston back in the tube, which forces oil through the restricted openings in both the piston rod head and the piston valve. The resistance of the oil to passage through these small openings, supplementing the action of the oil buffer spring, checks the force of recoil and absorbs the damaging part of the shock. In the forward motion when the breech is closing, the valve lifts freely off its seat and the oil offers no resistance to the forward movement of the barrel extension. There is a relief valve

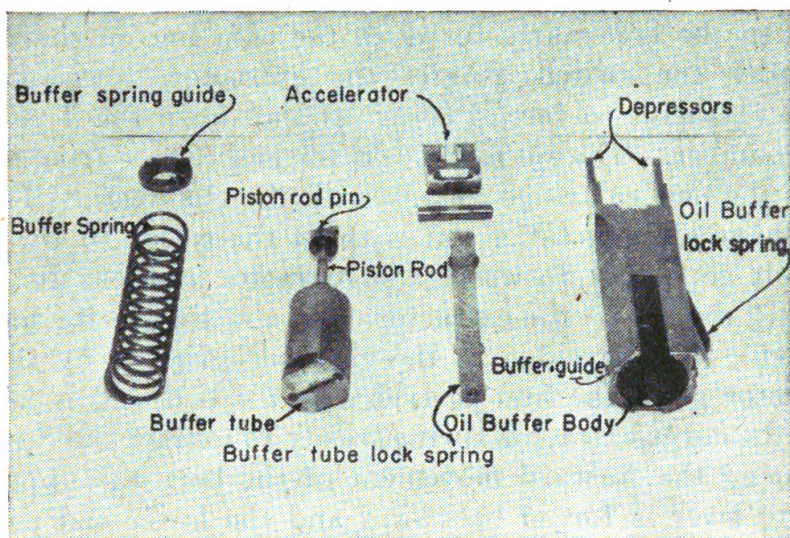


FIGURE 109.—Oil buffer group.

located in the buffer tube cap so that oil can escape if there is too high a pressure due to too much oil.

*Q.* When is the oil buffer group disassembled?—*A.* Only when necessary for repair, replacement of parts, or necessary instruction.

*Q.* How is the oil buffer group disassembled? *A.*—

(1) Drive out the accelerator pin and remove the accelerator. Push it on the end of the oil buffer piston rod until the oil buffer tube can be gripped with the hand. Pull the tube to the rear. The oil buffer tube lock spring and oil buffer spring lock may be removed by pushing to the rear. Unscrew the oil buffer tube cap and carefully pull out the oil buffer piston rod so as not to lose the buffer oil.

(2) Drive out the oil buffer piston head nut pin. Remove the oil buffer piston head nut, oil buffer piston rod head, and oil buffer piston valve. Unscrew the oil buffer packing gland plug and

remove the oil buffer packing gland ring, oil buffer gland packing, and oil buffer packing gland spring. When disassembling the oil buffer, care must be taken to note the position of the oil buffer piston rod head with reference to the end of the piston rod.

*Q.* How is the oil buffer group reassembled?—*A.* In general, in the reverse order of disassembling. When assembling the oil buffer piston valve and oil buffer piston rod head on the oil buffer piston rod, a space of from 0.04 to 0.05 inch should be allowed between the valve and the valve head.

*Q.* How is the .50 caliber oil buffer filled?—*A.* Hold the oil buffer tube with its base up throughout the filling operation.

(1) Remove both of the oil buffer tube filling screws from the base of the buffer tube.

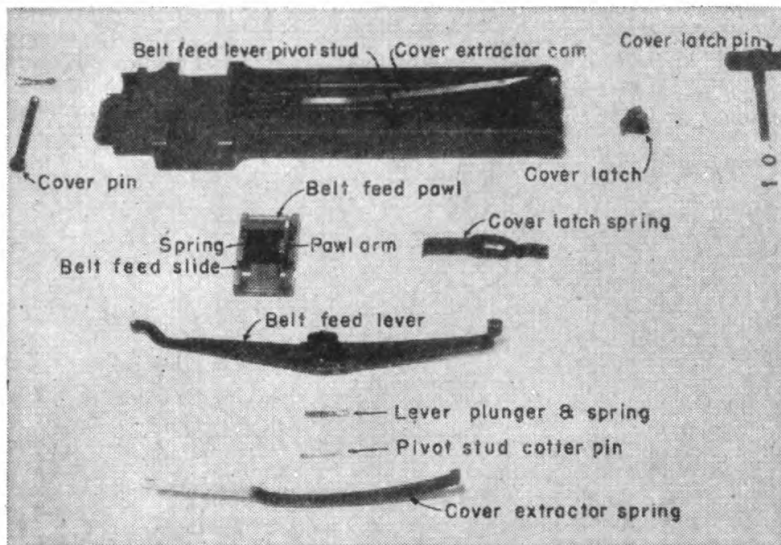


FIGURE 110.—Cover group.

(2) Fill the tube with machine-gun recoil oil, U. S. Army Spec. No. 2-77 (or any light recoil oil in an emergency), using the oil buffer filling oiler. Be sure to maintain a constant flow of oil whenever the oiler is inserted in the tube. Repeat the operation until the tube is overflowing.

(3) Replace the filling screws. Any excess oil in the tube will be relieved by the relief valve.

*Q.* Can the speed of firing be regulated by means of the oil buffer?—*A.* Yes. Turning the buffer tube clockwise tends to cut off or close the oil passages, which allows it to absorb more recoil and to reduce the rate of fire. Turning the buffer tube counterclockwise allows the oil passages to open and the oil to pass through larger throttling ports, which increases the rate of fire. To adjust, insert a screw driver blade into the slot in the rear of the oil buffer

tube through the hole in the backplate, and turn the required number of clicks, clockwise or counterclockwise, depending on whether a slower or faster rate of fire is desired. The buffer tube is held in an adjusted position by the buffer tube lock spring.

*Q.* How does the switch work?—*A.* The extractor moves forward and up during the last part of counterrecoil. As it reaches the last

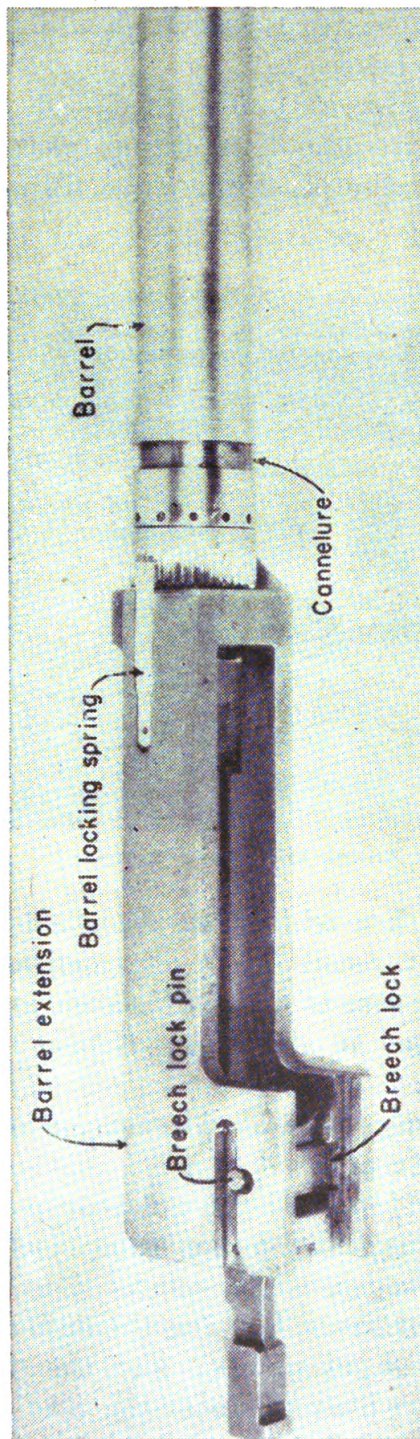


FIGURE 111.—Barrel group.

part of its travel forward, the stud on the side of the extractor, riding up on the slope of the extractor cam, pushes up on the switch against the switch spring and forces it up. As soon as the extractor has passed the end of the switch, the switch snaps back into place.

**116. Machine-gun mount.**—*Q.* What are the two types of anti-aircraft machine-gun mounts?—*A.* The M2 pedestal mount and the M1 tripod mount.

*Q.* What method of fire control may be used with each type of mount?—*A.* The M2 mount is suited for either central tracer control or individual tracer control. The M1 mount, unless supplemented by nonstandard equipment, can be used only when individual tracer control is employed.

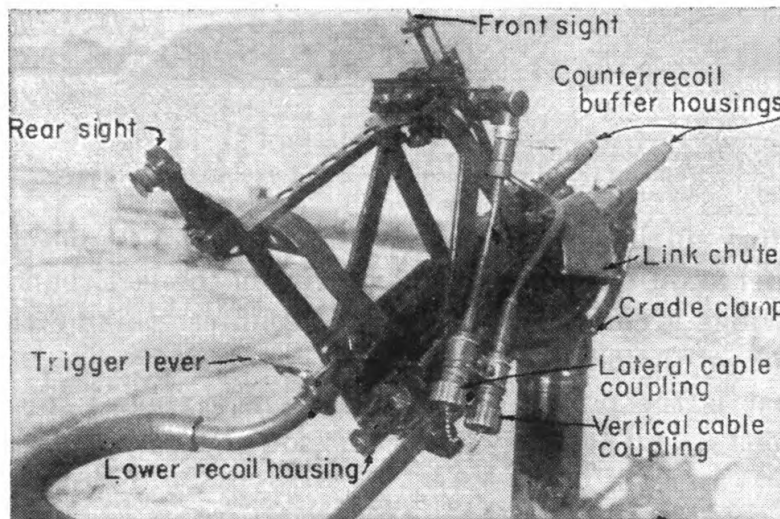


FIGURE 112.—Cradle of the M2 mount.

*Q.* What are the advantages of the M2 mount as compared with the M1 mount? *A.*—

(1) The pedestal type mount causes less interference with the movements of the gunner.

(2) A recoil mechanism is provided which takes up part of the shock of firing.

(3) A sighting mechanism is provided which can be connected to a central control station by means of flexible cables.

(4) A trigger mechanism is provided which permits firing the gun by means of the side plate trigger.

*Q.* Describe the recoil mechanism.—*A.* The recoil mechanism consists of three recoil springs, one component spring, two counterrecoil buffer springs, and related guides, slides, and housings. The lower recoil spring and the component spring are housed in the lower recoil spring housing, which is located between the side plates at the

rear of the cradle. One upper recoil spring and one counterrecoil buffer spring are located in each of two housings on opposite sides of the trunnion bearing at the front of the cradle. As the gun recoils, the trunnion bearing slides and the lower recoil slide move to the rear, compressing all three recoil springs and the component spring. The built-up spring pressure brings the gun to rest and then returns

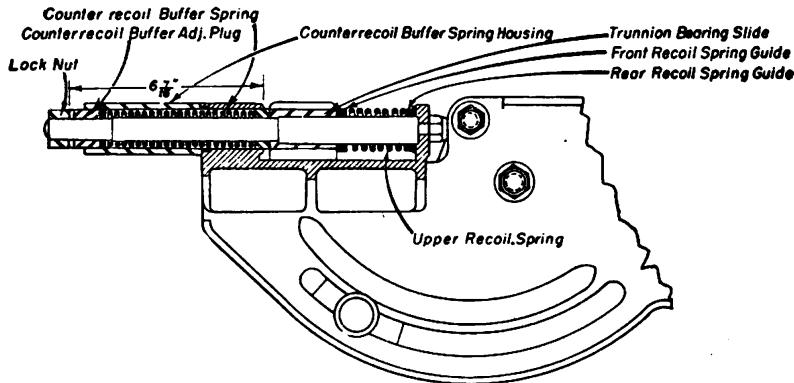


FIGURE 113.—Upper recoil and counterrecoil mechanism.

it to battery during counterrecoil. Counterrecoil is checked by the two counterrecoil buffer springs. Except on the last round fired, the buffer springs are aided at the end of counterrecoil by the impulse of recoil from the next round.

*Q.* What is the purpose of the component spring and how does it function?—*A.* The purpose of the component spring is to com-

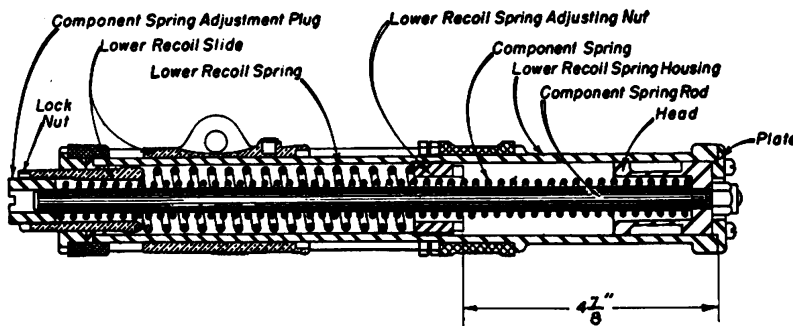


FIGURE 114.—Lower recoil mechanism.

pensate for the variation in the weight component of the gun at different elevations. This is accomplished by a gear and rack arrangement which automatically varies the compression of the component spring as the gun is elevated and depressed.

*Q.* Who makes adjustments to the recoil and trigger-control mechanisms of the M2 mount?—*A.* Only thoroughly qualified personnel. In the field they will be made by the chief of section or the artillery mechanic.

*Q.* What is the maximum elevation of the M2 mount?—*A.* 68½°.

*Q.* What guns can be mounted in the M2 mount?—*A.* The caliber .50 machine gun is the gun normally mounted in the M2 mount. However, if adapters are used, the caliber .30 machine gun may be fired from the mount.

**117. Care and cleaning of machine guns.**—*Q.* What is the most important task of care and cleaning to be done on a machine gun?—*A.* Cleaning and care of the bore.

*Q.* Describe the method of cleaning the bore. *A.*—

(1) Disassemble the gun.

(2) Place the barrel muzzle down in a vessel containing hot water and issue soap, a solution of soda ash, hot water, or in the absence of these, cold water. Insert a cleaning rod with a cleaning patch

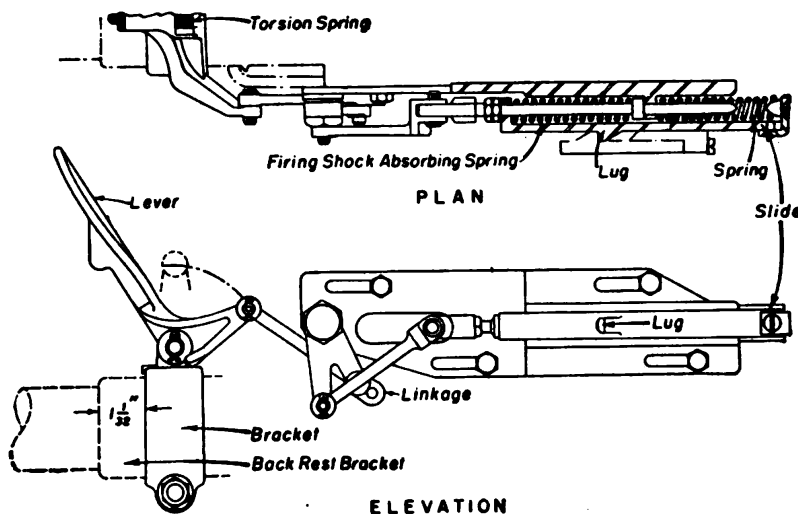


FIGURE 115.—Trigger control mechanism.

attached into the breech and pump the cleaning solution back and forth through the bore for about 1 minute.

(3) While the bore is wet, run a brass or bronze wire brush all the way through the bore, then all the way back, three or four times. Then pump the water solution through the bore again.

(4) Wipe the cleaning rod dry, remove the barrel from the water, and thoroughly dry the bore and chamber, using clean, dry flannel patches.

(5) Apply a light coat of lubricating oil.

(6) Inspect and clean the guns each day for 3 days following the cessation of fire.

*Q.* When may ammonia swabbing solution be used?—*A.* After the bore has been cleaned with one of the water solutions, wet a number to cut flannel patches with the ammonia swabbing solution and

swab the bore with these, generally for about 5 minutes, or until the patches no longer show a blue color. Then swab again with water and dry and oil the bore.

**Q.** How is ammonia swabbing solution made?—**A.** Ammonia swabbing solution may be made by mixing  $1\frac{1}{2}$  parts of 28 percent ammonia with 1 part of water. A stronger solution may be made by taking ammonium persulfate, 60 grains or  $\frac{1}{2}$  level spoonful; ammonia 28 percent, 6 ounces or 12 spoonfuls; and water, 4 ounces or 8 spoonfuls. Dissolve the ammonium persulfate in the water and add the ammonia. Keep in a tightly corked bottle. The ammonia swabbing solution will have little effect on the heavy, lumpy metal fouling which sometimes occurs when the older bullets jacketed with cupronickel are used. It is intended for use in connection with the newer ammunition, loaded with bullets jacketed with copper (gliding metal).

**Q.** How should the rest of the gun be cleaned? **A.**—

(1) The receiver should be wiped clean, care being taken to remove dirt and lint from the belt holding pawl.

(2) The cover, bolt, lock spring, barrel extension, and backplate should be wiped thoroughly clean, using a small stick covered with a flannel patch to remove dirt from all recesses.

(3) The water jacket should be wiped clean and muzzle gland tightened and repacked if necessary.

(4) All parts should now be wiped with an oily rag.

**Q.** How should machine guns be treated before being stored or shipped?—**A.** When machine guns are stored, even for a short period, or when they are to be shipped either by rail or water, they should be cleaned and prepared with particular care.

(1) The bores of all barrels should be cleaned with the standard metal fouling solution, thoroughly washed with water to insure that all traces of the solution are removed, and then dried.

(2) All parts of the gun should be cleaned and then rubbed dry with rags. In damp climates particular care must be taken to see that the rags are dry. After drying any part, the bare hands should not touch that part, but it should be handled with an oily rag.

(3) All metal parts should then be heavily coated with rust-preventing compound, semisolid, which should be warmed slightly and applied with a brush.

(4) The bores should be plugged and poured full of rust-preventing compound, the surplus poured out, the plug removed, and the bore allowed to drain.

(5) Then, handling the gun with oiled rags, it should be placed in the gun box, the wooden supports having previously been painted with rust-preventive compound.

*Q.* How should the guns be treated when taken out of storage?—

*A.* Machine guns, when issued from storage, are normally found completely coated with heavy grease. Grease may be removed by the use of gasoline or kerosene as may be convenient, or wiped from the parts with a cloth. In all cases where gasoline or kerosene are used for cleaning purposes, care should be taken to see that they are completely removed from the parts by wiping, washing with soap and water, and drying. All surfaces having been wiped clean, they should then be protected with a thin film of lubricating oil applied with a rag. Particular care must be taken to see that all grease is removed from bores and chambers before firing, as grease in these parts may cause high and dangerous breech pressure, or the barrel may burst on firing if it is filled with heavy grease.

*Q.* What general care should be given the mount?—*A.* For the M1 mount, keeping the parts of the mount free of dirt and grit and exposed metal surfaces and moving parts lubricated with oil is all that is necessary. For the M2 mount, in addition, the various parts of the trigger-control and recoil mechanisms must be carefully cleaned and oiled periodically, using a light lubricating oil such as SAE 10. The slides of the recoil mechanism should be lubricated every 2 hours of continuous firing. The elevating and traversing screws of the front sight mechanisms should be lubricated with a few drops of oil once a day. When assembling the mount, contact surfaces must be cleaned and all screw fastenings oiled to facilitate assembly and disassembly and to prevent corrosion. All parts of either mount which are painted when issued should be kept properly protected by paint.

**118. Packing barrel of machine gun.**—*Q.* What is the purpose of packing the barrel?—*A.* The movement of the barrel in recoil prevents the use of a permanent seal to hold water in the water jacket of the gun. Barrel packing must therefore be used between the barrel and the front and rear ends of the water jacket to prevent leakage. If the packing is too loose, water will leak. If the packing is too tight, the gun will not function smoothly.

*Q.* What material is used for packing?—*A.* Asbestos. The packing for the caliber .30 barrel is issued in long strands about 1 yard in length. The packing for the caliber .50 gun is formed packing of the proper size. Packing should be well soaked with oil before it is used.

*Q.* How is the caliber .30 barrel packed? *A.*—

(1) *Breech end.*—Place the packing in the cannellure and press it home with a screw driver and the thumb. Wind it around the barrel, pressing up against the wall of the cannellure. As the end is crossed on the first turn, see that it is bound down flat. On the last turn force the end under and see that it is bound down flat and worked well in. If the packing appears too thick, insert the breech end of the barrel into a hole in the trunnion block. Push forward gently and twist the barrel until the packing is worked down to a proper fit.

(2) *Muzzle end.*—When the gun is assembled, with or without the bolt, allow the bolt to go forward or trip the accelerator so that the barrel is fully forward. Remove the muzzle gland. Wind the the packing in even layers about the barrel with the first coil as close as possible to the end cap. Push back the muzzle or draw back and hold the bolt, at the same time guiding the packing into its seating. Screw in the muzzle gland and test the friction of the mechanism by pulling back and releasing the bolt handle several times. If there appears to be too much friction, remove one or two coils of packing. The muzzle gland must be screwed up so that its shoulder is against the metal of the end cap and is not stopped by jamming against the packing.

*Q.* How is the caliber .50 barrel packed?—*A.* Formed barrel packings are inserted in the cannellure at the rear end of the barrel and inside the front end of the water jacket.

(1) *Breech end.*—Unscrew packing adjusting ring and remove the old barrel packing from the cannellure. Clean the cannellure and insert the new packing. Smooth the packing until the ends meet. Screw the packing adjusting ring against the packing to hold it in place. For proper functioning the packing must be flush with the surface of the barrel. If the packing appears to be too thick, proceed as for the caliber .30 barrel.

(2) *Muzzle end.*—Unscrew the jam nut and lock screw on the under side of the front end of the water jacket. Unscrew and remove the muzzle gland. Remove the muzzle packing ring and the old front barrel packing. Clean out the inside of the front barrel bearing, insert the new front barrel packing, and replace the muzzle packing ring and muzzle gland. Screw the muzzle gland lightly against the ring and packing as the gland will be adjusted and locked in place after the barrel is reassembled in the gun. Reassemble the barrel assembly into the gun, being careful not to injure the barrel packing. Adjust the front barrel (muzzle) packing

by tightening or loosening the muzzle gland, and then lock in place with the front barrel bearing lock screw and jam nut. Adjust the rear barrel (breech) packing by tightening or loosening the packing adjusting ring, using a packing ring adjusting wrench and a barrel-holding wrench. Test the free movement of the recoiling parts of the gun by pulling and releasing the bolt several times. If there is too much friction, work the bolt until the barrel moves forward and rearward smoothly.

**119. Head space adjustment of machine gun.**—*Q.* What is the most important adjustment on a machine gun?—*A.* The head space adjustment.

*Q.* What may happen if the head space adjustment is not correct?—*A.* If the adjustment is not tight enough, the explosion of the cartridge may pull a case in two, leaving the front part in the chamber and preventing the entrance of the next cartridge. If the adjustment is too tight, either the recoiling parts will not go home so that the gun can be fired or excessive strain on the breech lock and breech lock pin will break the barrel extension in firing.

*Q.* How is the head space adjustment made?—*A.* The adjustment is made with the gun fully assembled. Pull the bolt to the rear about three-quarters of an inch. Screw the barrel into the barrel extension (using the point of a cartridge, or the combination tool, inserted in the barrel notches) until the action will *just close* (recoiling parts will go fully forward) without being forced. Then unscrew the barrel two notches.

*Q.* What precautions must be taken during this adjustment?—*A.* Care must be taken to avoid roughening the barrel surface during the adjustment. Care must also be taken that the packing does not bind the barrel, as a false adjustment will result in such a case.

*Q.* How is the adjustment tested?—*A.* The following test should always be applied prior to firing the gun:

(1) Work the bolt by hand two or three times. If the breech does not lock and unlock smoothly, unscrew the barrel one notch.

(2) Raise the cover and extractor. Move the bolt slightly to the rear by means of the bolt handle (caliber .30) or retracting slide (caliber .50). If the bolt moves independently of the barrel, the adjustment needs tightening. Readjust by screwing up one notch and test again. There must be no rearward movement of the bolt independent of the barrel, prior to unlocking of the breech.

**120. Malfunctioning of machine gun.**—*Q.* What is a runaway gun?—*A.* A gun that fires continuously without the trigger being depressed.

*Q.* What causes a runaway gun?—*A.* A bent, worn, or short trigger, or a burred or worn sear.

*Q.* How can firing be stopped on a runaway gun?—*A.* By twisting the belt where it enters the receiver. The gun should be kept pointed at a safe place in the field of fire until firing has been stopped.

*Q.* How is a runaway gun repaired?—*A.* Disassemble the bolt and barrel extension from the gun, examine them for defective parts, and correct the defects.

*Q.* What is a stoppage?—*A.* A stoppage is any unintentional cessation of fire.

*Q.* What is immediate action?—*A.* Immediate action is the procedure used for the prompt reduction of usual stoppages.

*Q.* What are the chief causes of stoppages?—*A.* Improper head space adjustment, defective ammunition, and broken or worn parts.

**121. Replacement of parts.**—*Q.* Is it quicker to change barrels by the water-saving method or by draining?—*A.* By saving the water, because of the time required to drain and refill the jacket.

*Q.* How are barrels changed? *A.*—

(1) *Retaining water in water jacket.*—(a) Remove backplate, bolt, and driving spring assemblies from the gun.

(b) Push in on the oil buffer lock spring (or the trigger pin for caliber .30) and pull oil buffer (or lock frame) to the rear from one-fourth to one-half inch.

(c) Release the cradle clamp, depress the muzzle of the gun below the horizontal, and then unclamp the cradle.

(d) Hold a plug at the muzzle of the barrel. (The steam cork plug wrapped in patches of cloth is suitable with the caliber .30 machine gun.)

(e) Withdraw the oil buffer (or lock frame), barrel extension, and barrel to the rear. As the barrel is withdrawn follow it with the plug or steam plug cork and insert it in the hole in the end cap or muzzle gland through which barrel has been withdrawn.

(f) Place a plug or twisted patch in the muzzle of the new barrel.

(g) Unscrew the old barrel from the barrel extension and replace with the new barrel.

(h) Reassemble barrel, barrel extension, and oil buffer assemblies into gun. When the muzzle of the new barrel passes through the hole in the end cap, remove both the plug or steam plug cork in the hole and the plug in the barrel. Run a patch through the barrel. Reassemble bolt, driving spring, and back plate assemblies into gun. Make headspace adjustment.

(i) Care must be exercised in removing and assembling the barrel not to disarrange the packing. Very frequently in assembling the new barrel the front packing is carried out by the muzzle.

(2) *Draining water from water jacket into water chest.*—After draining the water follow, as far as applicable, the general procedure outlined in the preceding case.

*Q.* How should a minor part be replaced if haste is necessary?—*A.* Change the entire part or assembly that includes it. If the firing pin is broken, change bolts; if the ejector is broken, replace the extractor.

## SECTION II

### 37-MM GUNS

|                               | Paragraph |
|-------------------------------|-----------|
| Functioning-----              | 122       |
| Disassembly and assembly----- | 123       |
| Care and preservation-----    | 124       |
| Mount-----                    | 125       |

**122. Functioning.**—*Q.* What are the major nonrecoiling parts of the gun?—*A.* The gun casing, trunnion block, recuperator cylinder, and feed box.

*Q.* What are the recoiling parts of the gun?—*A.* The tube, tube extension, recuperator piston rod and piston assembly, lock frame, and driving spring assemblies.

*Q.* Describe the action of the firing mechanism in firing the first round.—*A.* The gunner (vertical gun pointer) depresses his foot pedal to fire the gun. This acts through a linkage and the trigger bar, causing the trigger lever to pull the sear outward to the right. This allows the hammer to go forward. The hammer strikes the firing-pin assembly causing the firing pin to strike the primer of the cartridge, thus firing the round.

*Q.* Describe the action of the gun in recoil.—*A.* The tube, tube extension, and lock frame recoil to the rear with the empty cartridge case in the chamber. During recoil the rim of the case is gripped by the extractor which extends forward from the right of the lock frame. The tube and tube extension continue to the rear until the force of recoil is absorbed by the recuperator (normally about 10.6 to 10.75 inches). In the final rearward movement, the accelerator is rotated upward to the rear against the spring plunger by riding upward on the accelerator cam. The lock frame continues to the rear until it strikes the buffer plunger in the backplate which absorbs the final shock of its recoil. As the lock frame comes to the rear, the operating lever is rotated upward to the rear by the cam surfaces

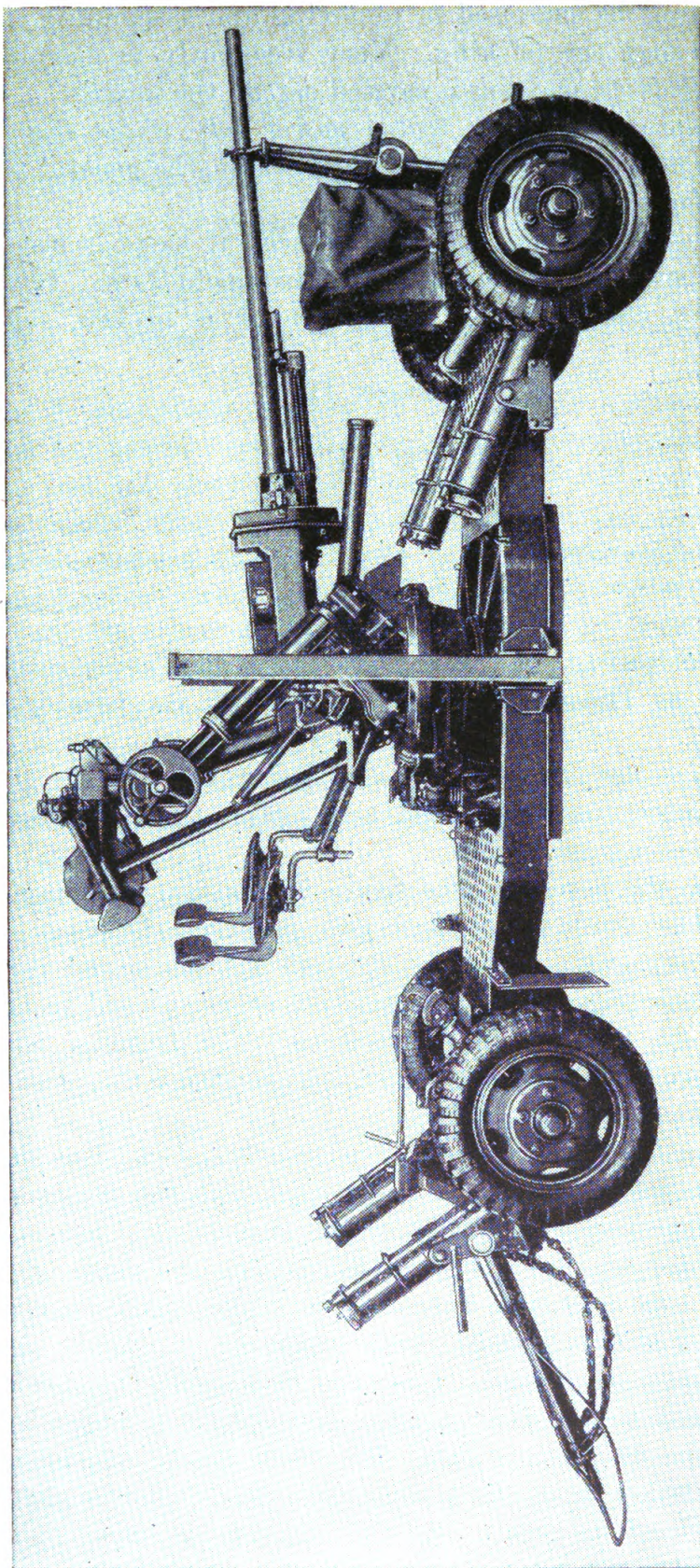


FIGURE 116.—37-mm antiaircraft gun in traveling position.

in the side plates. This causes the front end of the lever to rotate downward, pulling the breechblock downward into its open position, the operating lever spring to be compressed, the hammer to be cocked, and the driving springs to be extended. The rearward movement of the lock frame after the recoil of the tube and tube extension has been halted causes the extractor to withdraw the empty cartridge case from the chamber.

*Q.* Describe the action of the gun in counterrecoil.—*A.* The tube and tube extension return to the firing position under the action of the spring in the recuperator, the action being assisted by the accelerator. The lock frame is held in the rear position by the carrier dog until the new round fed into the receiver pushes the carrier catch to the right, allowing the front end of the carrier to spring down and the rear end to be raised. The lock frame drives forward under the action of the driving springs, forcing the new round into the chamber. As the tube extension goes forward, the ejector (located inside the left side of the tube extension) knocks the empty cartridge case down out of the extractor and ejects it from the gun.

*Q.* Explain how ammunition is fed to the gun.—*A.* As the tube extension comes to the rear, the feed lever stud on its right side forces the feed lever to the rear. This forces the front end of the feed crank to the right, causing the front end of the feed slide lever and the feed slide to move to the left until the slide grips the indentations in the top of the feeder clip at the new round. The clip holding pawl prevents the clip from moving to the left with the slide. As the tube extension moves forward, the feed lever stud forces the feed lever forward. This forces the front end of the feed crank to the left, causing the front end of the feed slide lever and the feed slide to move to the right, feeding the new round into the feed box. The feed slide moves to the right until the new round pushes the carrier catch to the right, allowing the carrier to spring downward. The carrier knocks the round down out of the clip so that the nose of the round is a little lower than its base. The charger of the lock frame, which was released by the upward movement of the rear end of the carrier, forces the round forward into the chamber. During this movement the base of the cartridge drops down until its rim is engaged by the extractor.

**123. Disassembly and assembly.**—*Q.* When should the gun be disassembled?—*A.* The gun should only be disassembled when necessary for essential training in matériel, for care and lubrication, or for replacement of broken or damaged parts.

*Q.* Describe the method of removing the tube.—*A.* Unscrew the two block bushing screws located on the sides of the trunnion block

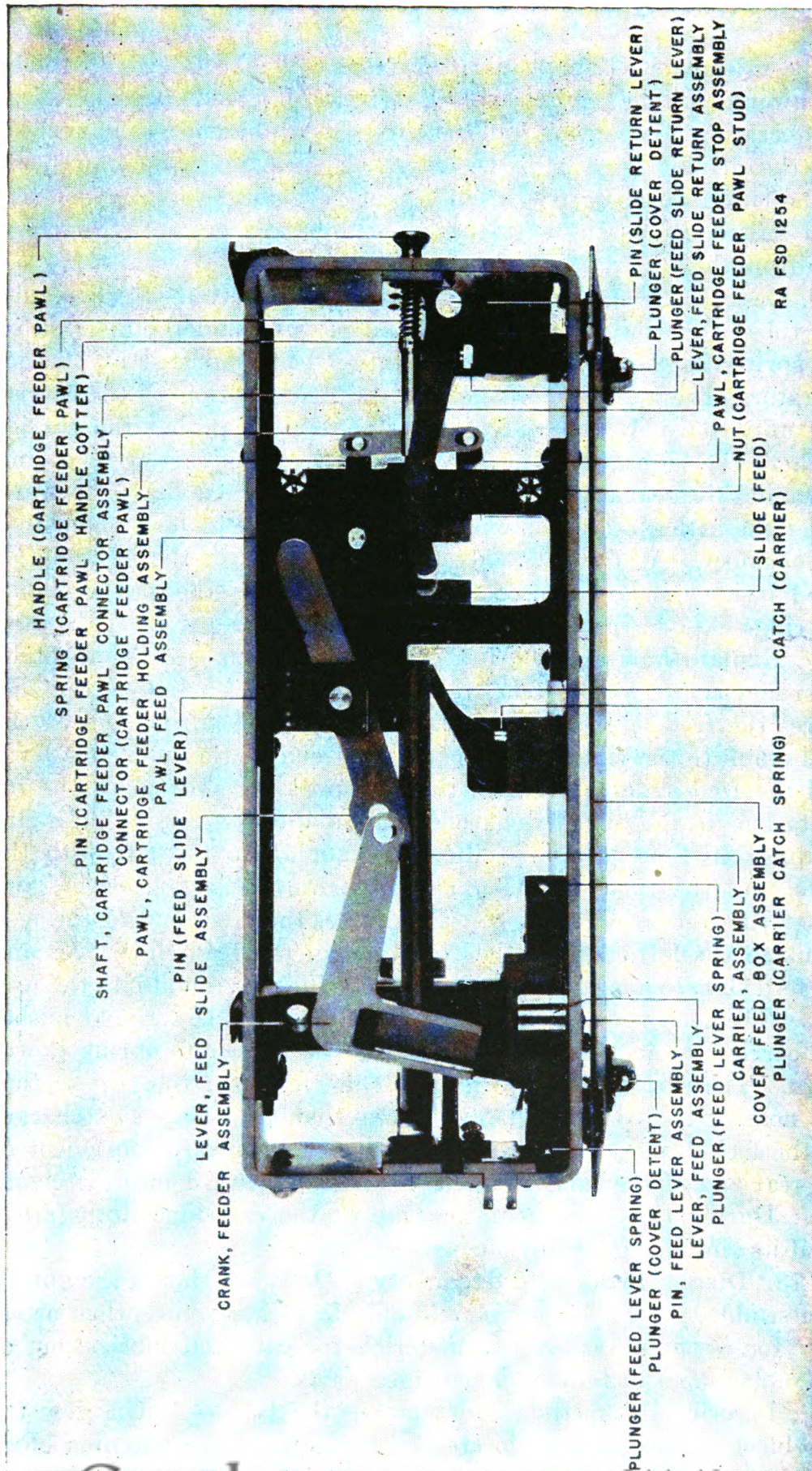


FIGURE 117.—Feed box, 37-mm anti-aircraft gun.

at its front end. Pull the lock frame to the rear until it is held back by the carrier dog. Place the centering device on the recuperator cylinder. (If no centering device is available, one member of the gun section must constantly support the muzzle throughout the operations of removing and replacing the gun tube.) Place the tube wrench in the slots provided for it in the tube. Push in the tube latch lock on the front of the feed box and hold the latch back until the tube is rotated about 1 inch with the tube wrench. The tube lock can then normally be released. However, rotation of the tube against the lock in firing may cause the lock to stick. If this occurs, tap the lock lightly until it is disengaged from the tube. Turn the tube counterclockwise by hand until the threads are disengaged from the tube extension and then pull the tube forward out of the gun. The block bushing is removed from the gun by the rear shoulder on the tube as the tube is pulled forward.

*Q.* Explain how the tube is replaced.—*A.* Reverse the operations of removing the tube. Be sure that the centering device is in place (or that a member of the section is supporting the muzzle). When the end of the tube has been pushed inside the block, rotate it counterclockwise until a distinct click is heard signifying that the end of the thread on the tube has passed the end of the thread in the block. Then screw in the tube in a clockwise direction using the hands. The wrench is used only for the last quarter turn. When the tube is in the correct position the latch will engage the notch in the tube. When the tube is assembled, see that the depressed portion of rear face of the tube is exactly aligned with depressed portion of corresponding face of tube extension. Improper alinement of tube and tube extension may cause the extractor to be broken and tube threads to be damaged.

*Q.* Why must the tube be supported when removing it from, and replacing it in, the gun?—*A.* It must be supported to prevent sagging. Failure to do this may cause burring or undue wear to the tube threads and tube extension threads.

*Q.* Describe the method of removing and replacing the breechblock.  
*A.*—

(1) *To remove.*—Pull the lock frame to the rear until it is held back by the carrier dog. Pull outward on the breechblock stop retaining pin at the bottom right side of the tube extension, releasing the breechblock stop. The breechblock will then drop out. If difficulty is experienced in pulling the retaining pin outward, push the breechblock up a little from the stop.

(2) *To replace.*—Reverse the operations given above. Be sure the breechblock is resting on the breechblock stop before letting the lock frame go forward.

Q. Describe the method of removing and replacing the lock frame.  
A.—

(1) *To remove.*—See that lock frame is in its forward position. Push the carrier catch to the right, allowing the carrier to spring downward. Pull the locking clips of the driving spring rod hooks outward and downward and disengage the hooks from the lock frame

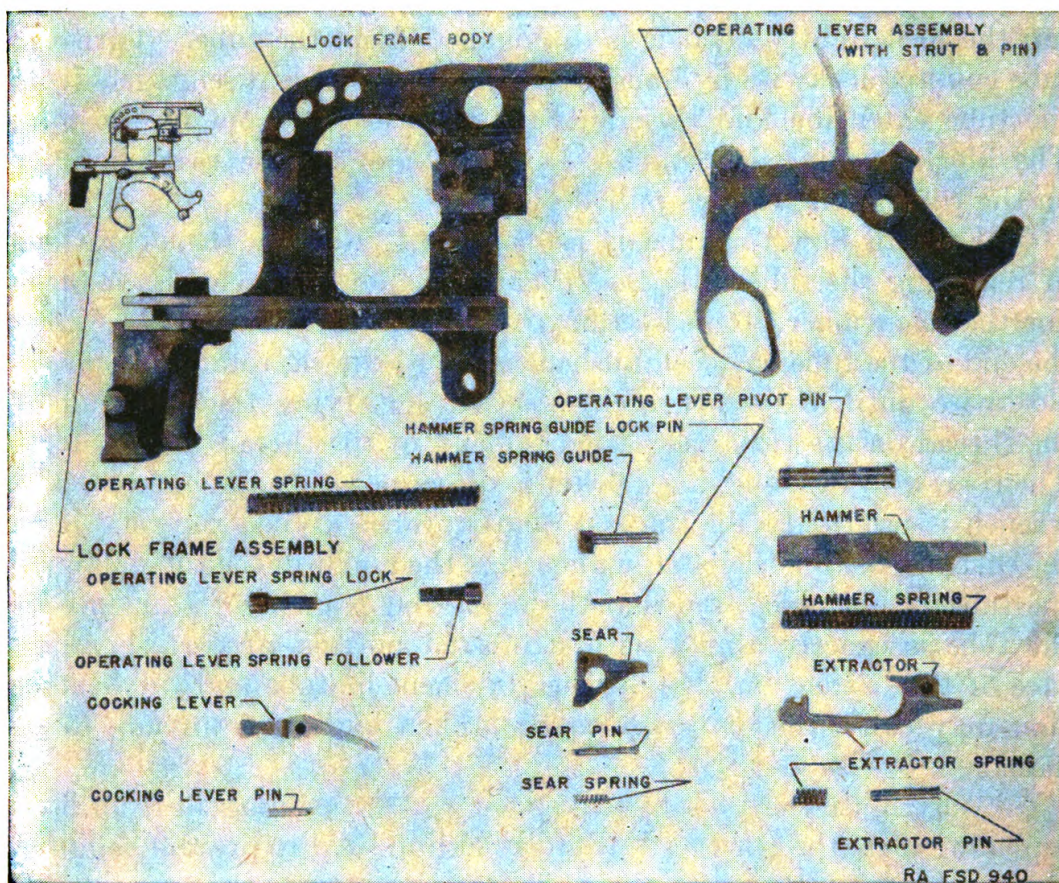


FIGURE 118.—Lock frame, 37-mm antiaircraft gun.

trunnions. Remove the backplate by pushing forward on the backplate latch located on the bottom of the right-hand side plate, and then forcing the backplate downward. Remove the lock frame from the gun, keeping a firm grip on the operating lever and the top of the lock frame to prevent the operating lever from springing forward and injuring the man disassembling the gun. When the lock frame has been removed from the gun, carefully swing the operating lever forward.

(2) *To replace.*—Reverse the operations given above. Before reassembling the lock frame, be sure that the carrier is down.

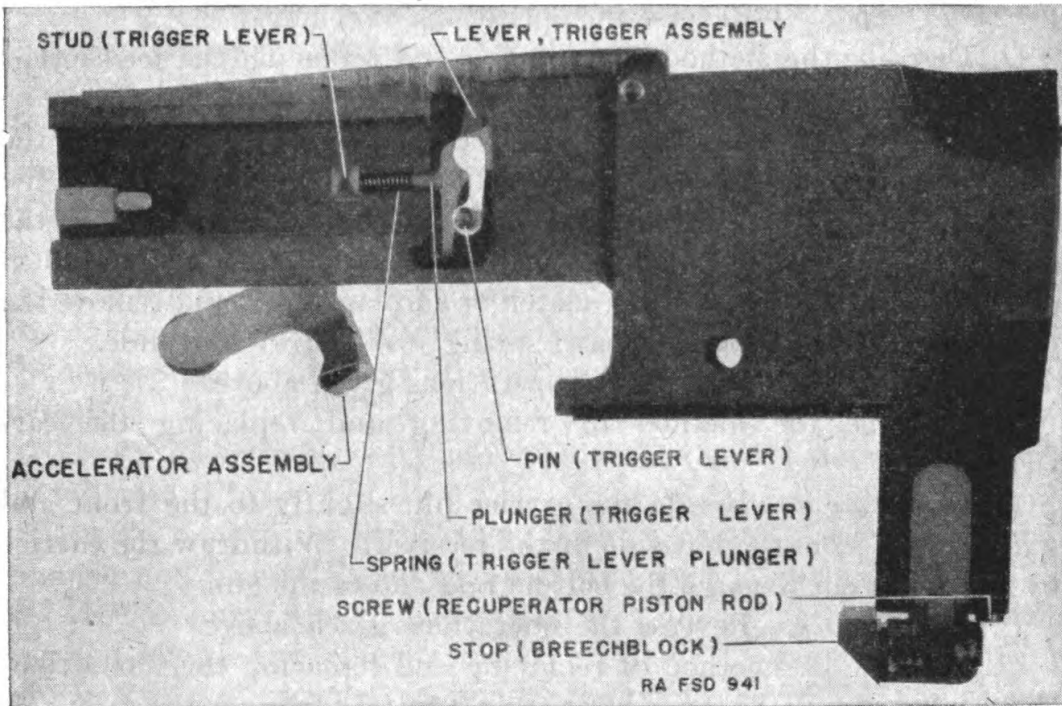


FIGURE 119.—Tube extension—left side view.

Q. Describe the method of removing and replacing the driving spring assemblies. A.—

(1) *To remove.*—The backplate and lock frame having been removed, remove the driving spring assemblies by pulling the assembly plungers to the rear and rotating the assemblies outward until they are clear of the tube extension. Then remove the assemblies to the rear.

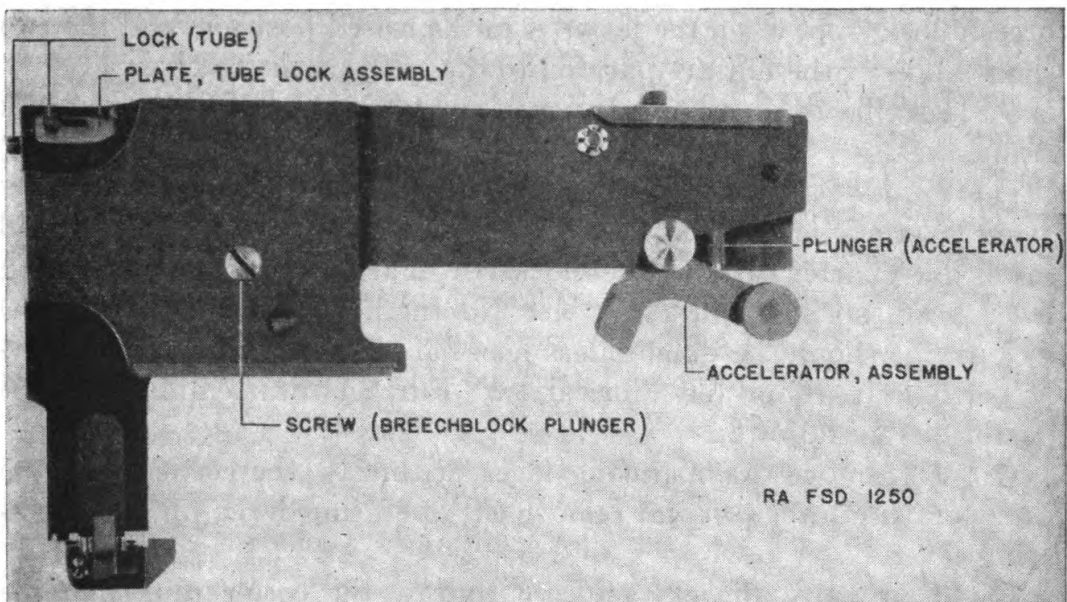


FIGURE 120.—Tube extension—right side view.

(2) *To replace*.—Reverse the operations of removal.

Q. Describe the method of removing and replacing the feed mechanism. A.—

(1) *To remove*.—Fold back the feed box cover. Withdraw the feed slide lever pin. Force the feed slide to the right and lift out the feed slide lever. Remove the feed lever pin from the right side of the receiver and lift out the feed lever. Remove the feed crank. Push in on the feed pawl pin with a match or similar object and remove the pin. Remove the pawl and pawl spring. Withdraw the slide.

(2) *To replace*.—Reverse the operations given above.

Q. Describe the method of removing and replacing the carrier. A.—

(1) *To remove*.—Rotate the carrier pin slightly to the front and withdraw it from the left side of the receiver. Withdraw the carrier by passing it out through the bottom rear end of the gun.

(2) *To replace*.—Reverse the operations given above.

Q. Describe the method of removing and replacing the tube extension. A.—

(1) *To remove*.—Remove in order the backplate, lock frame, driving spring assemblies, breechblock, feed mechanism, carrier, tube, and accelerator cam. With the gun in horizontal position, unscrew the recuperator piston rod nut and pull the tube extension out to the rear. *Do not have the gun elevated while the piston rod nut is being unscrewed and the tube extension removed.*

(2) *To replace*.—Reverse the operations given above. The gun must be horizontal. The recuperator piston rod nut is screwed in until its outer face is just flush with the inner face of the lip of the breechblock stop, when the latter is in the raised position, and the two short edges of the nut are parallel to the sides of the receiver.

Q. Describe the method of disassembling and assembling the lock frame. A.—

(1) *To disassemble*.—Insert a screw driver in the slot in the operating lever spring head at the rear of the lock frame, rotate the head about one-quarter turn counterclockwise, and withdraw the operating lever head, spring, and follower. No further disassembling of the lock frame should be done unless necessary for replacement of parts or periodic cleaning and lubrication. Further disassembling can be performed as follows:

(a) To remove the operating lever, withdraw the cotter pin from the operating lever pin and remove the operating lever pin and operating lever.

(b) To remove the extractor, withdraw the cotter pin from the extractor pin and remove the extractor pin and extractor.

(c) To remove the sear, withdraw the cotter pin from sear pin and remove the sear pin and sear.

(d) To remove the hammer and cocking lever, withdraw the cotter pins from the hammer pin and cocking lever pin. Remove the hammer pin and cocking lever pin. Withdraw the hammer and the cocking lever.

(2) *To assemble*.—Reverse the operations above. After the cotter pins are inserted each one must be bent around the corresponding pin so that it does not interfere with the operation of the gun.

*Q.* Describe the method of disassembling and assembling the tube extension. *A.*—

(1) *To disassemble*.—After removing the tube extension, proceed as follows:

(a) To remove the accelerator, push in on the accelerator spring plunger and remove the accelerator, plunger, and spring.

(b) To remove the trigger assembly, pull out on the trigger trip pin and remove the trigger trip. Push in on the trigger lever spring plunger with a screw driver, remove the trigger lever pin, and remove the trigger lever and assembly. Remove the plunger and spring.

(c) To remove the ejector, withdraw the cotter pin from the ejector stud nut and remove the ejector nut and ejector spring.

(d) To remove the breechblock stop, withdraw the cotter pin from breechblock stop pin and remove the stop pin and breechblock stop.

(e) Do not perform the operations in (c) and (d) above unless necessary for the replacement of parts or periodic cleaning and lubrication.

(2) *To assemble*.—Reverse the operations given above.

**124. Care and preservation.**—*Q.* How is the bore cleaned?—*A.* With hot water and issue soap, a solution of soda ash, hot water, or in the absence of these, cold water. Insert the metal bore brush in the muzzle. Elevate the gun slightly, pour some of the cleaning solution in the muzzle, and then work the brush back and forth the length of the tube several times. Flush the bore with clear water. Examine the bore and if it is not clean, repeat the cleaning operation. When the bore is clean, place burlap or cotton rags on the end of the rammer staff and work the staff back and forth in the tube until the bore is dry. When the bore is thoroughly dried, apply light lubricating oil by means of a brush, cotton rags, or burlap attached to the rammer staff. The soda ash solution is prepared by dissolving one-half to 1 pound, depending upon the strength desired, of soda ash (sodium carbonate cleaning compound) in 1 gallon of boiling water. The soda ash solution is prepared at the time it is to be used.

*Q.* How is the recoil system checked? *A.*—

(1) Before firing, the recuperator is checked to insure that it is filled with oil. The length of recoil is also checked after the gun is fired.

(2) Before filling the recuperator cylinder, elevate the muzzle about  $5^{\circ}$  above the horizontal. At this elevation the cylinder cannot be completely filled. Remove filler plug which is located at the front end of the recuperator cylinder and air plug at the rear of the expansion chamber. Fill recuperator with light recoil oil until oil is just visible in the bottom of the recess in the bottom of the filler plug hole. Slap outside walls of recuperator cylinder with the hands. This action will force the escape of any air trapped in the cylinder. Con-

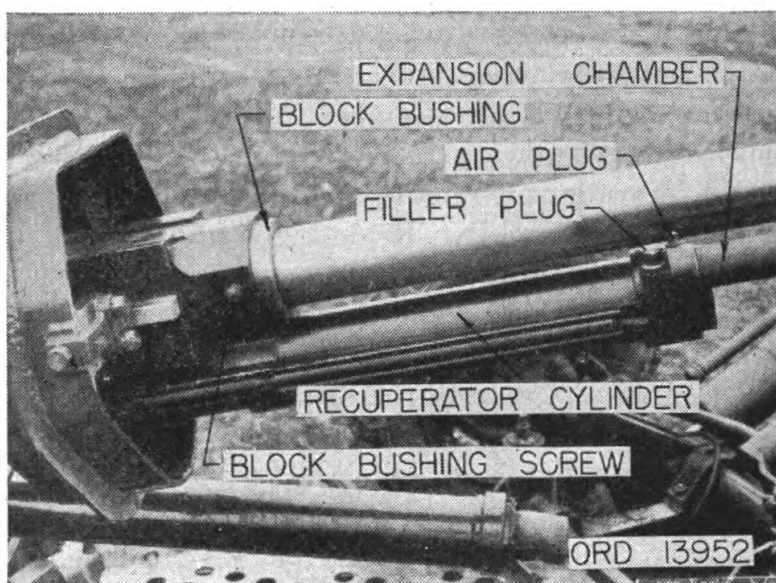


FIGURE 121.—Recuperator.

tinue filling and jarring the cylinder until all air is removed, the oil remaining stationary at the bottom of the filler plug hole when the cylinder is slapped. Replace the filler plug and then the air plug.

(3) The normal length of recoil is 10.75 inches. To measure the length of recoil, spread a thin film of grease on the tube for 12 or more inches forward from the block bushing. Fire a round from the gun. Measure the distance that the grease has been pushed forward on the tube by the bushing. This distance is the length of recoil. If the length of recoil is too great, elevate the muzzle to more than  $5^{\circ}$  and put a few additional drops of oil in the recuperator. If the length of recoil is too small, depress the gun to less than  $5^{\circ}$  and remove a few drops of oil. Then recheck the length of recoil by firing another round.

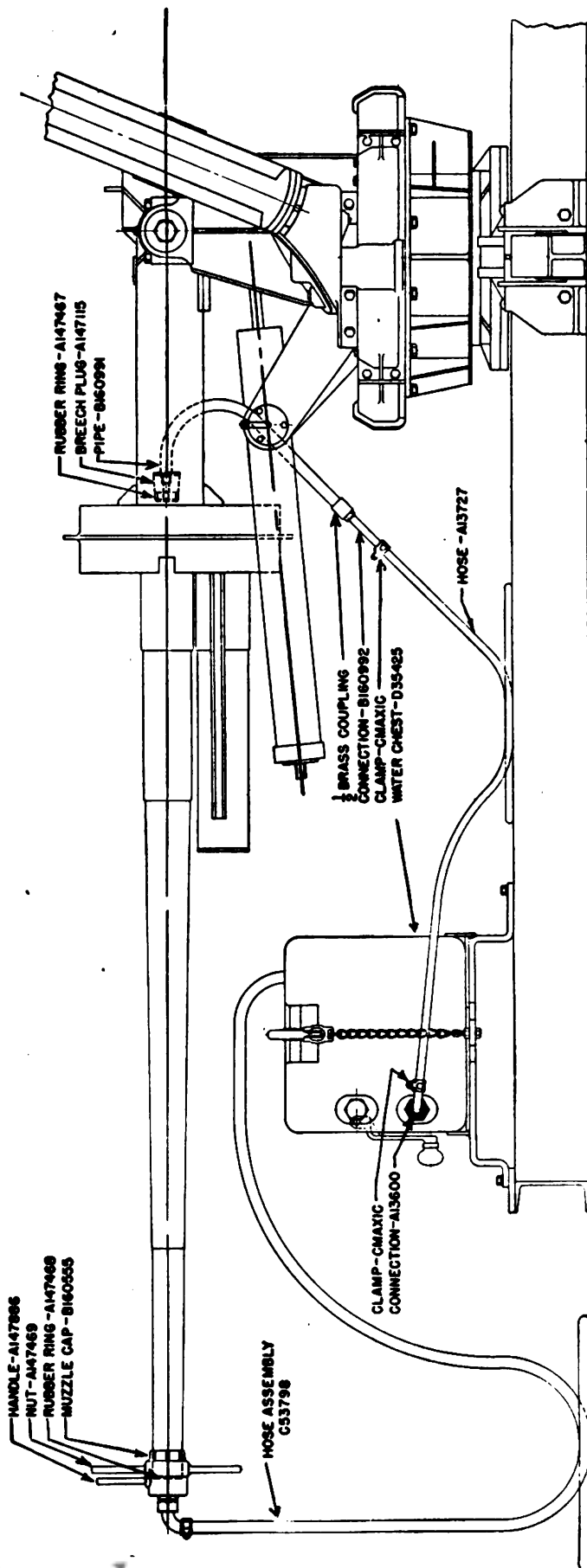


FIGURE 122.—Gun cooling assembly.

**Q.** How is the tube cooled?—**A.** Before attempting to cool the gun tube, elevate the gun to about 30°. To cool the tube, pull lock frame to the rear, insert brass tube of water delivery hose in breech end of tube, and then ease lock frame forward to hold brass tube in place. Pump water through tube until steam is replaced by a flow of water. Attach water return hose to muzzle of gun by means of brass clamping attachment. Pump water through the barrel for 2 or 3 minutes. Pumping is continued until a man can place his bare hand lightly on the tube without danger of being burned. When the gun has been cooled, pull lock frame to the rear, withdraw brass tube of water delivery hose, and allow water to drain from tube. Then unfasten clamping attachment of return hose. When first handling the cooling

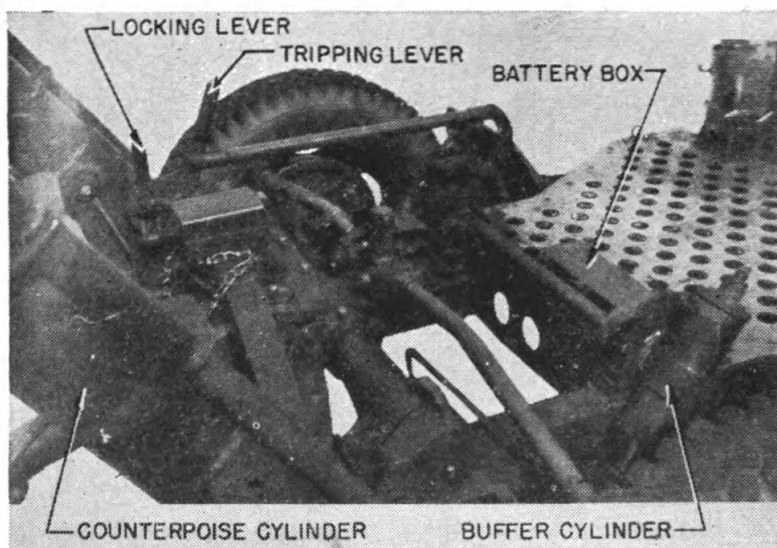


FIGURE 123.—Arrangement of front wheels of mount, 37-mm antiaircraft gun.

equipment, personnel must be cautioned about danger from escaping steam.

**125. Mount.**—**Q.** What is the standard mount for the 37-mm antiaircraft gun?—**A.** The M3 mount.

**Q.** How long does it take to drop the mount into firing position from the traveling position?—**A.** 20 to 30 seconds.

**Q.** What are the limits of elevation?—**A.** 0° to 85°.

**Q.** What are the limits of traverse?—**A.** 360° traverse.

**Q.** What is the purpose of the equilibrator?—**A.** To counterbalance the muzzle preponderance of the gun caused by placing the trunnions near the breech. It assists in the elevating and depressing of the gun.

**Q.** What is the purpose of the buffer cylinders?—**A.** To take up the road shock when the mount is being towed.

**Q.** What is the purpose of the counterpoise cylinders?—**A.** To assist in lowering and raising the wheels of the mount.

**Q.** What is the standard sighting system?—**A.** The sighting system M2.

**Q.** What brakes are provided?—**A.** Electrical and mechanical. The electrical brakes are used normally and are controlled from the towing vehicle. The mechanical brakes are used when the mount is parked in the traveling position and when maneuvering the gun by hand.

**Q.** How is the gun bore sighted?—**A.** Before bore sighting the gun, the carriage must be level and the telescopic sights properly in place. Remove the backplate and lock frame from the gun. Sight the gun on a distant point, using the bore sights provided. Turn the cable couplings of the sighting system until the lines in the telescopic sights coincide with the distant point on which the gun is sighted. Remove the screws from the deflection counters of the sighting system and lift out the counters. Turn the worm of each counter until the counter reads 500 and then replace the counter and screws.

**Q.** How are the gun sights synchronized with the control box which controls the movement of the sights during firing?—**A.** Bore sight each gun independently. Set the adjusting dials of the control box at zero and the lead dials at 500 (normal). Hook up the flexible cables between the control box and the gun sighting systems. The gun sights are now properly synchronized.

### SECTION III

#### DUTIES OF MEMBERS OF SQUAD OR SECTION

Duties of members of machine-gun squad or 37-mm gun section..... Paragraph 126

**126. Duties of members of machine-gun squad or 37-mm gun section.**—The candidate should be required to demonstrate practically his ability to instruct members of the machine-gun squad or 37-mm gun section. Duties of members of the machine-gun squad and of the 37-mm gun section are outlined in TM 4-325.

### SECTION IV

#### SELECTION OF POSITION AND EMPLACEMENT

Selection of position..... Paragraph 127  
Emplacement of machine guns and 37-mm guns..... 128

**127. Selection of position.**—**Q.** What is the normal antiaircraft machine-gun fire unit?—**A.** The machine-gun platoon of four guns.

Q. What is the normal 37-mm AA gun fire unit?—A. The 37-mm AA gun platoon of two guns.

Q. How are the machine guns mounted when on the march?—A. When there is any possibility of aerial attacks during the march, the guns are mounted in their trucks, ready for firing, with the mounts secured so that they are rigid enough for traveling and firing but can be readily dismounted without delay.

Q. How are the four guns of the machine-gun platoon arranged when emplaced on the ground?—A. In order that fire may be opened on a target approaching from any direction with the minimum possible delay, the guns are located approximately on the corners of a square. Each gun of the platoon is assigned a normal sector of about  $90^\circ$  and is responsible that any target appearing in that sector is brought under fire promptly. The remaining guns of the platoon will also open fire on the target as soon as possible.

Q. What points must be considered when selecting a position for AA automatic weapons? A.—

(1) There must be a clear all-around field of fire down to  $2^\circ$  for at least 1,000 yards from the position. In addition, there should be a clear all-around field of fire down to  $5^\circ$  for 2,500 yards for 37-mm gun platoons. Where these requirements cannot be met, observers in communication with the position should be placed on the far side of any obstructions. Failure to consider this point may reduce seriously the time during which targets may be brought under fire.

(2) The position should be convenient to a road to make it easy to get in and out of position but not so near that fire at low angles will interfere with traffic.

(3) The immediate vicinity of road intersections and other prominent terrain features should be avoided since the enemy is liable to shell or bomb such places.

(4) The position should be suitable for fire on hostile mechanized vehicles, provided that the choice of such a position does not interfere with the accomplishment of the antiaircraft mission.

Q. Should positions in or near a woods be selected?—A. No. Positions near woods or other obstructions must be avoided unless time for clearing is available. Even then such positions are undesirable since the clearing gives away the gun position.

Q. In concealing a gun position, what is the most important factor to be considered?—A. The selection of a locality which lends itself readily to concealment of the gun and crew.

Q. What sort of an area is best from this viewpoint?—A. One with a confused pattern such as an area covered with low brush.

**Q.** Should the gun emplacement have overhead protection other than camouflage?—**A.** No. Such protection would interfere with the firing of the gun at high elevations. Even the camouflage must be so constructed that it can be removed instantly when desired.

**Q.** How should the guns be placed to get the best concealment?—**A.** Each gun should be located so that it becomes a part of an existing clump of bushes, a brush pile, or some other vague and irregular feature of the terrain.

**128. Emplacement of machine guns and 37-mm guns.—Q.** Who directs the work of organizing the individual gun emplacement?—**A.** The squad leader or gun commander.

**Q.** What are his duties in organizing the position? **A.—**

(1) He sees that the maximum possible protection and concealment are provided for the emplacement.

(2) He sees that the field of fire is improved by the clearing away of brush and other obstructions.

(3) He takes advantage of all natural cover and increases its value by constructing earthworks.

(4) He erects camouflage to protect the position against both ground and aerial observation.

**Q.** What duties does the chief of section perform in the occupation of the position? **A.—**

(1) He leads his section to the position designated by the platoon commander, designates the location for each gun, supervises the unloading of the squads and their equipment and the setting up of the guns, and instructs the squad leaders as to the amount of ammunition to be placed at the firing positions.

(2) He instructs squad leaders as to where to send their ammunition details for ammunition and water and as to what concealment and security are to be provided.

(3) He enforces camouflage discipline in his section according to instructions received from the platoon commander.

**Q.** Next to proper choice of position, what is the most important factor in effective camouflage?—**A.** Camouflage discipline.

**Q.** What does the term camouflage discipline mean?—**A.** Camouflage discipline involves confining movements to designated routes, closing nets when not firing, repairing or replacing covering material when necessary, keeping men under concealment when enemy airplanes are overhead, not allowing smoke to appear near the position, keeping ammunition covered, not allowing trucks or other vehicles to stop on the road near the position in daylight, not permitting transportation to turn around near the position, and similar measures to prevent discovery.

*Q.* If overhead camouflage is installed, what material is usually used to support it?—*A.* Chicken wire or fish net.

*Q.* How are these nets used?—*A.* They are supported on stretched wires and garnished with natural materials such as brush and grass or with artificial camouflage material such as strips of dyed burlap.

*Q.* How should the net be made to look?—*A.* Like the surrounding area.

*Q.* What is the best way to judge the effectiveness of camouflage?—*A.* Viewing it from the air.

*Q.* What are the three parts of an antiaircraft automatic weapons emplacement?—*A.* The gun emplacement proper, the ammunition supply trench, and the belt or clip loading station. The gun emplacement proper and the belt or clip loading station are about 50 yards apart and are connected by the ammunition supply trench.

*Q.* Describe the gun emplacement proper. *A.*—

(1) The gun emplacement proper for a machine gun should consist of a large, circular hole about 5 feet deep and large enough in diameter so that the squad can operate the gun through the entire field of fire. Normally the hole is from 7 to 10 feet in diameter. Where time is limited, a shallower hole supplemented by a sandbag or earth parapet built to the height of the gun trunnions may be substituted.

(2) A sandbag parapet will normally be constructed around the 37-mm gun rather than to have it emplaced in a hole. This is to prevent the loss of mobility of the gun.

*Q.* Describe the ammunition supply trench.—*A.* It is a simple trench running from the gun emplacement proper to the belt or link loading station. It should be about 4 feet deep and wide enough for two men to pass.

*Q.* Describe the belt or link loading station.—*A.* The belt or link loading station is located in a pit from 4 to 6 feet deep and large enough to accommodate the belts or links, the link loading (or belt filling) machine, the designated amount of ammunition, the ammunition chests, and the loading personnel.

*Q.* What is a revetment?—*A.* A revetment is a covering or protection for the sides of a pit or trench which prevents the earth walls from caving under their own weight or under the action of weather or of personnel using the pit.

*Q.* Name some good types of revetments.—*A.* Sandbags, sod, chicken wire, or brush mats supported by poles or stakes, or stakes driven close together.

*Q.* When should revetment be used?—*A.* When the emplacement is dug in soft earth or sand, provided time is available. Revetment should not be used unless necessary.

**Q.** How may surface water be excluded from a trench or pit?—**A.** By digging an intercepting ditch on the uphill side to catch and divert water running down the slope.

**Q.** Describe ways of draining a trench.—**A.** If the trench is built on a hillside, drainage ditches can be dug so that the water will flow off downhill. If this is not practicable, a deep hole, called a sump, into which the water can drain can be dug at the lowest part of the trench or pit.

**Q.** If clearing must be done, how should the material cut away be disposed of?—**A.** It may be used for camouflage or carried away and hidden.

**Q.** In digging the trenches and pits, how should the excavated earth be disposed of?—**A.** It should be placed in sandbags and used for protection, piled for protection and then sodded, or carried away and placed in wheel tracks of roads or hidden under cover.

## SECTION V

### PREPARATION FOR SERVICE PRACTICE

|                                       | Paragraph |
|---------------------------------------|-----------|
| Training of personnel.....            | 129       |
| Check and adjustment of matériel..... | 130       |
| Safety precautions.....               | 131       |

**129. Training of personnel.**—**Q.** What procedures should govern the assignment of personnel in preparation for firing?—**A.** Personnel for the key positions must be carefully selected and trained. In the machine-gun platoon the key men are the machine gunners, the adjusters, and the spotters. In the 37-mm gun platoon the key men are the gun pointers, the loaders, the adjusters, and the spotters. At least two men must be thoroughly trained in the duties of each of these positions.

**Q.** Into what phases may the training be divided?—**A.** Into three phases: preliminary training, preliminary firing, and record firing.

**Q.** What instruction does the preliminary training include?—**A.** Preliminary training includes instruction in nomenclature, disassembling and assembling the gun or machine gun, the method of changing spare parts, manipulation of the gun and mount, use of the sights, drill of the squad or the gun section and of the range section, clearing of stoppages, general care and adjustment of the gun and mount, the handling of ammunition, and the care and operation of the fire-control equipment.

*Q.* How is smoothness of firing data obtained?—*A.* By training all men who track the target or match pointers to turn their hand-wheels at as even a rate as possible under all conditions.

*Q.* How can the possibility of casualties, real or assumed, best be prepared for?—*A.* By having each member of a section become familiar with the duties of all men in the section. This can be done by changing assigned positions during drill.

*Q.* What does preliminary firing include?—*A.* Preliminary firing includes firing at balloons and at towed sleeve targets. Balloon firing is conducted using caliber .30 machine guns mounted on the M2 mount (machine guns) or on subcaliber mounts on the 37-mm gun. Balloon firing should be very brief, being intended only to familiarize inexperienced gunners with the handling of the gun and mount and to permit range section personnel to observe readily the results obtained by changing the leads at the control box. As the result of preliminary firings, the men best qualified for the key positions are selected.

*Q.* What is the purpose of record firings?—*A.* Record firings are employed to give additional training to the selected personnel and to determine the state of training attained by the platoon.

**130. Check and adjustment of matériel.**—*Q.* In checking the matériel before firing, what elements should receive special attention?—*A.* Any which have failed before.

*Q.* Where can you find out what elements have failed during previous firing?—*A.* A permanent record is kept in the gun book of all malfunctionings during firing.

*Q.* What are some of the elements of guns and carriages that should be checked? *A.*—

- (1) Examine the sights to see that they are in good condition.
- (2) See that recoil cylinders are full and that recoil and counter-recoil systems are in proper adjustment.
- (3) Dismantle, clean, lubricate, and reassemble breechblocks.
- (4) Test firing mechanisms, including safety features, and make any adjustments necessary.
- (5) Thoroughly clean bores and powder chambers.
- (6) Test traversing and elevating mechanisms for smoothness of operation and make any adjustments that may be necessary.
- (7) See that no oilholes have been overlooked and that all grease cups have been filled and adjusted.
- (8) Check shafts and gears connecting pointing mechanisms with data indicators.

*Q.* What are some of the elements of fire-control apparatus that should be checked? *A.*—

(1) Run check problems through the fire-control apparatus to insure its proper operation.

(2) Check the operation of the data transmission system.

(3) See that all sights and telescopes are in proper adjustment, including the reduction of parallax and backlash to a minimum.

(4) Check the synchronization of the data transmission system immediately before firing.

*Q.* What is the most important record kept by the gun commander?—*A.* A gun record in which the following is entered immediately upon completion of firing:

(1) The total number of rounds fired by each barrel, obtained by consulting the last entry for that barrel and adding thereto the number of rounds just fired.

(2) The parts replaced during the firing. The contents of the spare-parts box should be checked and completed as soon as possible. When the parts listed in the record are replaced in the spare-parts box the entries in this column are crossed out.

(3) The repairs or parts needed, to show parts that were not available or repairs that could not be made when the record was filled out. When these parts are obtained, or the repairs are made, the entry in this column is crossed out.

(4) Any information of importance, such as fired tracers, rapid rate, belts tight, excessive vibration, and repairs to tripod needed, is entered under "Remarks."

(5) When a barrel is no longer a part of the squad equipment, entries pertaining to that barrel are crossed out.

**131. Safety precautions.**—*Q.* Who must supervise all firing?—*A.* An officer in charge of firing. He is assisted by a safety officer who is responsible for determining the safety of the field of fire and (when firing at towed targets) of the towing airplane.

*Q.* What danger signal is displayed while firing?—*A.* A large red flag is flown from a conspicuous location near the firing point at all times when firing is going on.

*Q.* When may guns be loaded?—*A.* Guns may be loaded only at the command "Load" given by the officer conducting the firing.

*Q.* How should ammunition be placed with relation to the guns?—*A.* So that it cannot be ignited or exploded by an accident at the guns. It must also be in a dry place protected from the direct rays of the sun.

*Q.* Who has the authority to give the command **CEASE FIRING** in case of danger?—*A.* Anyone in the military service who sees the danger.

Q. What type of device does the safety officer usually use as a signal for CEASE FIRING?—A. A siren or other device with a loud and distinctive sound.

Q. What are safety pointing observers?—A. They are observers stationed in rear of the guns to assist the safety officer.

Q. What are their duties?—A. They aid the safety officer in protecting the towing plane, shipping, and other property and individuals against errors in pointing the piece. When such errors are noted the safety pointing observer stops the firing.

Q. What is the principal purpose of testing firing mechanisms just before firing?—A. To insure the proper operation of safety features.

Q. What are the rules about smoking near the gun?—A. Smoking is not allowed near the gun or ammunition.

Q. What is done to make sure that a gunner is aware of the command CEASE FIRING?—A. A designated individual taps him on the back or hand.

Q. When is live ammunition allowed at the gun?—A. Not until firing is about to begin.

Q. In what state are machine guns kept except when firing or about to fire?—A. Unloaded and with covers partially raised.

Q. While tracking the target, when may the gunner touch the trigger?—A. When his sights are alined on the target and the field of fire has been indicated as safe.

Q. How must automatic weapons be pointed at the beginning of courses?—A. Considerably below the elevation of the towing airplane until it has cleared the line of sight.

Q. Where must an automatic weapon be pointed while a stoppage is being cleared?—A. At a safe part of the field of fire.

Q. If the fire of a machine gun cannot be stopped by releasing the trigger, what should be done?—A. The firing should be halted by twisting the ammunition belt.

Q. When can personnel go in front of the guns?—A. No one is allowed in front of the guns unless permission has been granted by the officer conducting the firing. This permission is not given until all guns are unloaded.

Q. How are the lateral limits of the field of fire indicated?—A. By suitable reference points (flag markers or distinctive terrain features) readily visible from the gun positions.

## CHAPTER 9

## SEARCHLIGHTS

|   | Paragraphs |
|---|------------|
| SECTION I. Searchlight apparatus.....               | 132-139    |
| II. Troubles and remedies.....                      | 140-144    |
| III. Sound locator apparatus.....                   | 145-149    |
| IV. Tactical employment of searchlight section..... | 150-151    |

## SECTION I

## SEARCHLIGHT APPARATUS

|   | Paragraph |
|---|-----------|
| Types and general characteristics.....          | 132       |
| Sperry searchlights.....                        | 133       |
| General Electric searchlight.....               | 134       |
| Control stations (Sperry).....                  | 135       |
| Control station (General Electric).....         | 136       |
| Power plants.....                               | 137       |
| Orientation and synchronization.....            | 138       |
| Maintenance, care, and adjustment of parts..... | 139       |

**132. Types and general characteristics.**—The following tables present a general view of searchlight equipment. Very few lights of the models listed in table I are still in use and further details concerning them will not be included in the subject matter in this manual.

TABLE I.—Older equipment

| Model of light            | Type of distant electric controller | Model of control station | Power unit      |
|---------------------------|-------------------------------------|--------------------------|-----------------|
| 36-inch Mack.....         | None.....                           | None.....                | Mack, 5½-ton.   |
| 60-inch open (M1918)..... | do.....                             | do.....                  | Cadillac, M57.  |
| M-I.....                  | Impulse.....                        | M-I (d-c).....           | Cadillac, V-63. |
| M-II.....                 | do.....                             | do.....                  | Cadillac, M341. |
| M-III (experimental)..... |                                     |                          |                 |
| M-IV.....                 | Brush shifting.....                 | M-III (a-c).....         | Cadillac.       |
| M-V (experimental).....   |                                     |                          |                 |

TABLE II.—*Newer equipment*

| Model of light            | Type of distant electric controller | Model of control station            | Power unit        |
|---------------------------|-------------------------------------|-------------------------------------|-------------------|
| M-VI.....                 | Brush shifting.....                 | M-III (a-c).....                    | Duplex.           |
| M1934.....                | D-c step-by-step..                  | M1934 Binocular (Sperry).           | General Motors.   |
| M1937.....                | do.....                             | M1937 Binocular (Sperry).           | Duplex.           |
| M1939.....                | do.....                             | M1939 Binocular (Sperry).           | U. S. Motors.     |
| M1940 (Sperry).....       | do.....                             | M1940 Binocular (Sperry).           | Do.               |
| M1940 (General Electric). | A-c self-synchro-nous.              | M1940 Binocular (General Electric). | General Electric. |
| M1941 (Sperry).....       | D-c step-by-step.....               | M1941 Binocular (Sperry).           | Duplex.           |

**133. Sperry searchlights.**—*Q.* Describe the characteristics of the Sperry M1941 searchlight.—*A.* This is a 60-inch, 150-ampere light. It possesses the following characteristics:

- (1) A high-intensity arc as a source of light.
- (2) A current through the arc of 150 amperes with an arc voltage of 78 volts.
- (3) Automatic focusing of the positive crater, and continuous rotation of the positive carbon.
- (4) A ventilating system which exhausts the gases formed by the burning of the carbons.
- (5) Metal mirror.

*Q.* Is the M1941 Sperry searchlight much different in its characteristics from previous Sperry models? What are the differences?—*A.* No. The characteristics and operation of the M-VI, M1934, M1937, M1939, and M1940 searchlights are practically identical with the M1941 searchlight. The M-VI is equipped with a glass mirror. However, only M1941 provides for continuous rotation of the positive carbon, and has a time delay mechanism and thermal circuit breaker in the arc switches.

*Q.* How does the high-intensity arc function in the Sperry searchlight?—*A.* The incandescent ball of vapor which forms the source of light in the high-intensity arc is derived from the rare earths, cerium and lanthanum. By mixing these rare earths in the soft core of the positive carbon, and by forcing a high current through the carbon, the earths are volatilized and projected into the positive crater.

Electrons flow from the negative to the positive carbon and tend to keep the burning gases in the positive crater.

**Q.** Briefly describe how the Sperry automatic feed mechanism causes the positive and negative carbons to feed in the M1941 model.—

**A.** The feed motor operates at “arc” or “listening” load voltages. The feed motor drives the positive rod through a train of gears. A miter gear on the end of this rod drives another miter gear which is shafted to a yoke carrying a set of gears and a ratchet. The yoke also carries the positive carbon which rotates with it. When the feed plunger prevents rotation of a ratchet, which uses the yoke as a shaft, a planetary gear travels around a spur gear which is rigidly fastened to the ratchet, thereby causing the feed rollers to drive the positive carbon forward. On feeding sufficiently far forward, the plunger is disengaged and the large spur gear rotates freely with the yoke without there being any relative movement between this gear and the planetary gear. The feed motor also drives through an eccentric gear which causes the negative reciprocating feed member and the feed pawls to oscillate. Depending on the position of the negative feed control guard, the proper pawl will operate to drive the negative control rod in the direction necessary to feed the negative carbon forward or to retract it.

**Q.** Describe how the positive carbon is fed forward on the M1941 searchlight.—**A.** A positive feed control electromagnet is mounted on the positive head. When this electromagnet has current flowing through it, it attracts a feed plunger, causing the feed plunger to move into one of a series of holes machined in the side of the ratchet, thereby preventing the ratchet from rotating. Attached to the ratchet is a spur gear. Both the ratchet and the spur gear are mounted on, and can rotate with respect to, the yoke. The exterior surface of the yoke serves as a shaft and bearing surface for the bearing of the ratchet and spur gear. When the ratchet stops, the spur gear stops. A planetary gear is mounted on, and rotates continuously with, the yoke. This planetary gear meshes with the spur gear which is attached to the ratchet. When the ratchet and spur gear are stopped from rotating by the feed plunger the planetary gear “walks around” the spur gear which, through shafting and gearing, causes the positive carbon feed rollers to drive the positive carbon forward. The length of time the positive carbon feed contacts are closed may be controlled by means of a positive carbon feed rate adjustment screw, thereby allowing the positive carbon to feed forward at the desired rate of feed. When the positive feed control electromagnet has no current flowing through it the feed plunger is held away from the ratchet by a spring.

**Q.** There are two methods of causing current to flow through the positive feed electromagnet. What are these two methods? **A.**—

(1) *Normal automatic positive carbon feed.*—The feed motor, through gearing, rotates a positive control rod. Mounted on and rotating with this control rod is an eccentric cam. During each revolution of the cam its high surface closes electric contacts which allow current to flow through the positive feed control electromagnet, thereby causing the positive carbon to feed forward at a rate equal to one-half the rate of burning of the positive carbon.

(2) *By action of thermostat.*—When the positive carbon burns back  $\frac{1}{64}$  of an inch, rays of light coming from the positive crater are concentrated by the thermostat lens on the thermostat bimetallic strip. The bimetallic strip heats and bends so as to close the thermostat electric contacts before the positive crater burns back from the focal point more than  $\frac{1}{32}$  of an inch. This allows current to flow through the positive feed control electromagnet, thereby feeding the positive carbon forward to the focal point of the mirror.

**Q.** How does the automatic feed mechanism function in the M1940 and prior models?—**A.** The feed motor drives a disk which in turn drives an oscillating feed member forward (toward front of light) and rearward. On this oscillating feed member are mounted three pawls, one positive and two negative. The positive feed pawl engages a positive feed ratchet during the forward movement only of the oscillating member, thereby causing the positive carbon to feed forward and to rotate. The two negative feed pawls, one to drive the negative carbon forward, the other to retract it, engage with corresponding negative feed ratchets. The correct negative feed pawl engages with its corresponding feed ratchet during the rearward movement only of the oscillating feed member.

**Q.** How is the positive carbon on the M1940 and prior models fed forward?—**A.** The feed mechanism feeds the carbon forward so that the normal rate of feed is slightly less than the rate of burning of the carbons. The positive carbon is also rotated during this forward movement so as to cause the positive crater to burn evenly.

**Q.** What device keeps the incandescent ball of vapor at the focal point of the mirror?—**A.** A thermostat, in conjunction with the feed mechanism.

**Q.** How does the thermostat keep the positive carbon at the focal point of the mirror in the M1940 and prior models?—**A.** The thermostat control increases the rate of feed when the crater burns back. When the crater is out of focus to the extent of  $\frac{1}{64}$  of an inch, a pencil of light, focused by means of a lens, falls through a slit in the thermostat housing and strikes a bimetallic strip. Heat causes this

strip to warp and close a circuit to an electromagnet which draws a guard away from the positive feed pawl, thus increasing the rate of positive feed. The positive crater is thus restored to the focal point before it can get more than  $\frac{1}{32}$  of an inch out of focus. The rate of feed of the positive carbon can be regulated by the positive feed rate adjusting knob.

*Q.* Can the positive carbon be fed backward as well as forward?—

*A.* No. The feed mechanism allows the positive carbon to be fed forward only.

*Q.* Can the negative carbon be fed backward as well as forward?—

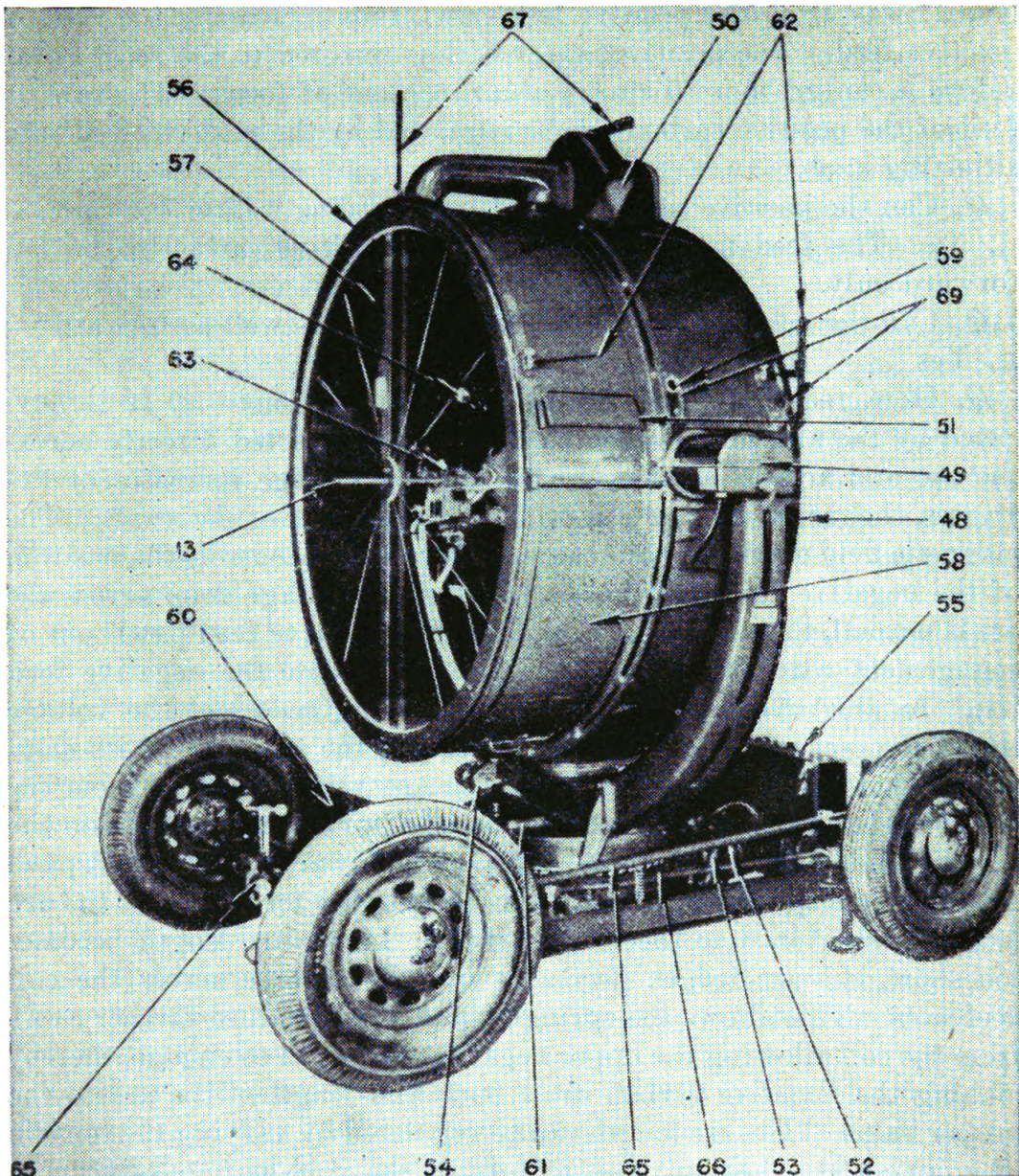
*A.* Yes.

*Q.* How does the negative feed control function?—*A.* It is governed by the arc voltage coil. This coil is connected directly across the arc and acts as a magnet. As the arc voltage increases or decreases, the magnetic strength of the coil increases or decreases. The magnetic field exerts a pull on an armature which controls the position of the negative feed guard. As long as the voltage drop across the arc is normal, the negative guard holds the negative feed pawls out of engagement with the ratchet wheels which rotate the negative feed rod. As the carbons burn back, the arc lengthens and the voltage across the coil increases, thereby increasing the strength of its magnetic field. The magnetic field of the arc voltage coil attracts the armature toward it against the action of a spring which pulls on the opposite side of the armature, allowing the lower negative feed pawl to become engaged. The negative carbon is fed forward and the arc length is shortened to the proper value. If the arc length becomes too short, the arc length decreases and the voltage across the coil decreases. This allows the spring to pull the armature farther away from the coil allowing the upper negative feed pawl to engage, thereby making the negative carbon draw back and lengthen the arc to the proper value. The arc length can be regulated by varying the tension of a spring attached to the armature of the voltage-regulating coil. The arc is struck automatically by the negative feed mechanism. When the switch is closed, the voltage coil receives full line voltage and the rate of feed is maximum, bringing the two carbons in contact.

*Q.* Can the positive and negative carbons be fed other than by automatic feed control? Explain.—*A.* Yes. They can be fed by semiautomatic feed control or by hand control.

(1) If the positive carbon feed develops trouble, the positive carbon may be fed by hand while the negative carbon continues to feed automatically.

(2) In a like manner, if the negative carbon feed develops trouble, the negative carbon may be fed by hand while the positive carbon



- |  |                                |
|--|--------------------------------|
| 13. Positive carbon.   | 57. Glass door.                |
| 48. Rear drum.   | 58. Sliding panel.             |
| 49. Elevation data receiver housing. (Not part of M1934 and M-VI lights. M-VI light has a transmitter instead of a receiver at this location.) | 59. Arc view peep sight.       |
| 50. Ventilating motor and exhaust vent.  | 60. Ballast resistor.          |
| 51. Ventilating flap intake vents.   | 61. Handhold plate.            |
| 52. Azimuth control motor.   | 62. Elevation daylight sights. |
| 53. Azimuth motor clutch lever.  | 63. Lamp unit.                 |
| 54. Azimuth scale lamp.  | 64. Recarboning lamp.          |
| 55. Junction box.  | 65. Steering tongue and lug.   |
| 56. Front drum.  | 66. Transportation bar.        |
|  | 67. Azimuth daylight sights.   |
|  | 69. Orienting sights.          |

FIGURE 124.—Sperry M1924 AA searchlight (front quarter view).

continues to feed automatically. The above two cases are "semiautomatic feed control."

(3) In case the automatic feeds for both the positive and negative carbons develop trouble, full hand control is used to feed the positive and negative carbons. A ground glass finder is used so that the source of light may be kept at the focal point of the mirror. When using the negative hand feed, the arc voltage must be kept at 78 volts by referring to the voltmeter.

*Q.* Why is a ventilating system necessary in drum type lights?—

*A.* The purpose of the ventilating system is to prevent the deposit of light-absorbing film on the interior surfaces, to cool the lamp head, and to exhaust gases and soot from the drum. One of the byproducts of the combustion has a *corrosive action* on the mirror so that a check should be made to insure the proper functioning of the ventilating system.

*NOTE.*—Always clean mirror and interior surfaces of drum immediately after use.

*Q.* What is the effect of improper focus?—*A.* Loss of beam intensity.

*Q.* What percentage of light is lost by allowing the positive crater to become  $\frac{1}{8}$  inch out of focus?—*A.* Approximately 40 percent.

*Q.* What are some other causes of loss of light?—*A.* Sputtering or unsteadiness of the arc, and deposits of vapor on the mirror and front door, both caused by excessive current across the arc.

**134. General Electric searchlight.**—*Q.* Describe the characteristics of the General Electric M1940 searchlight.—*A.* The searchlight is a 60-inch, 150-ampere light. It has—

(1) A high-intensity arc as a source of light.

(2) A current through the arc of 150 amperes with an arc voltage drop of 78 volts.

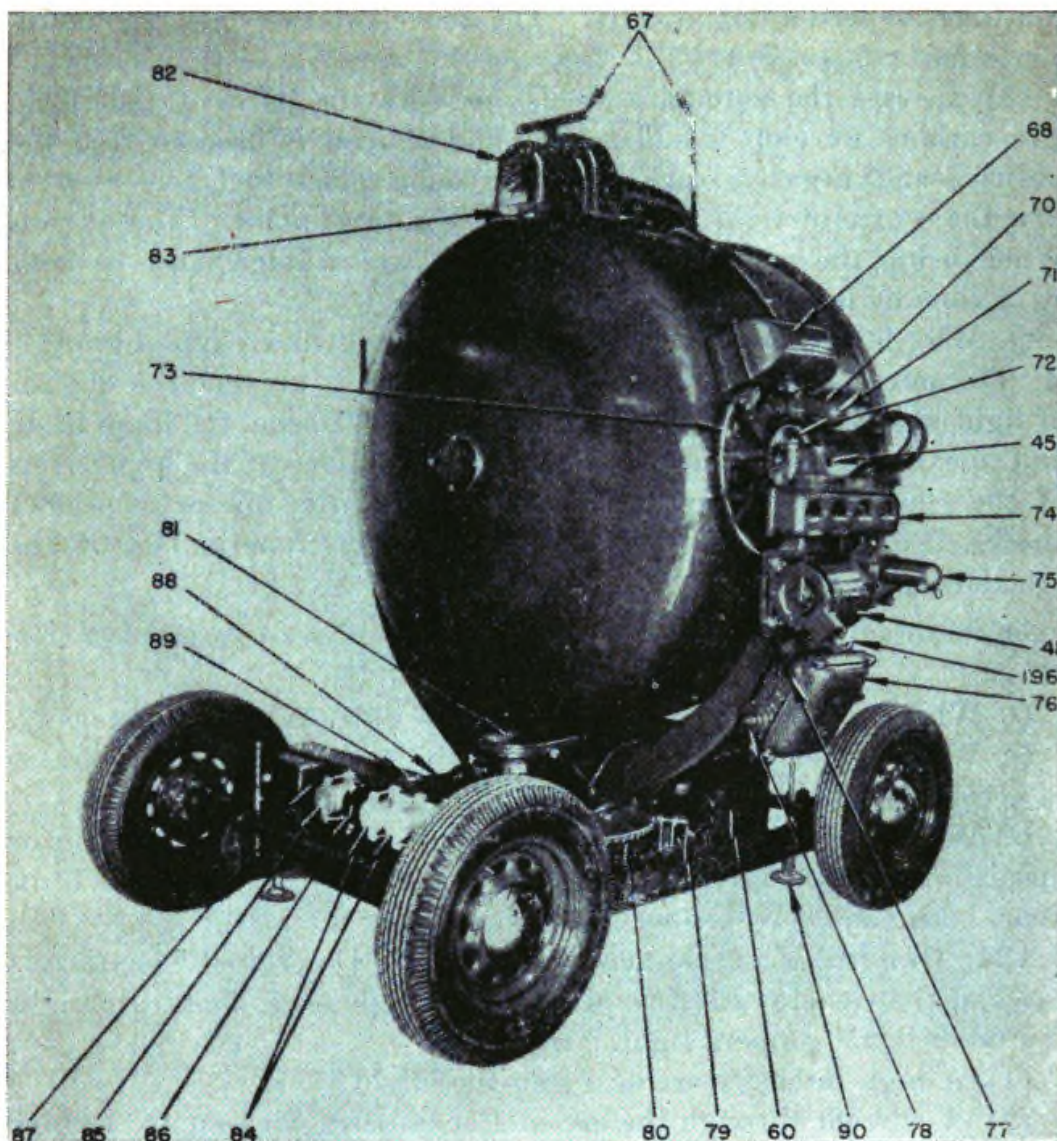
(3) Automatic focusing of the positive crater.

(4) A ventilating system to exhaust gases formed by the burning of the carbons.

(5) Metal mirror.

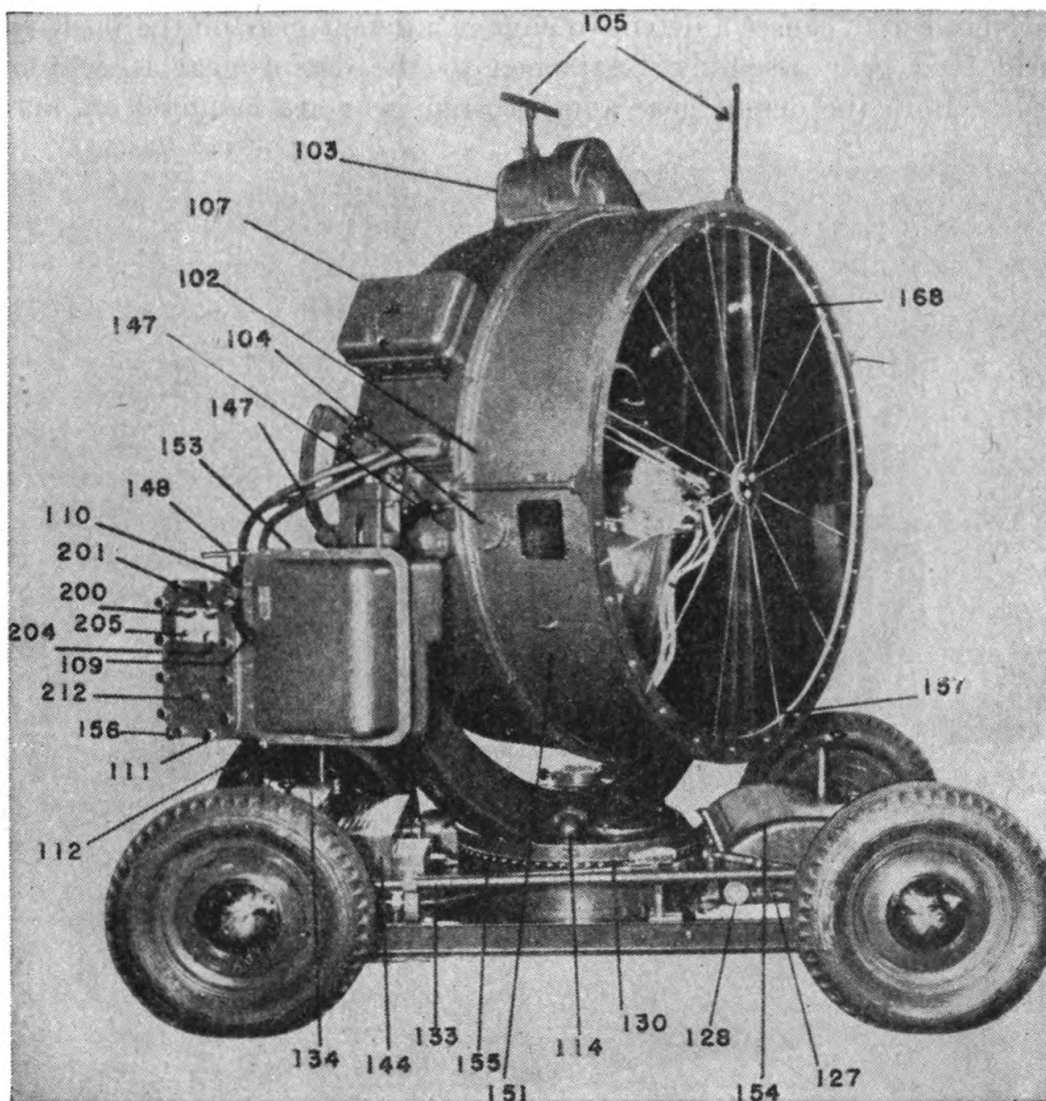
*Q.* Describe briefly how the General Electric automatic feed mechanism functions.—*A.* The feed motor operates at "arc" or "listening" load voltages. The armature shaft is geared on the front end (toward front of searchlight) to a positive drive shaft and is geared on the rear end to the negative drive shaft.

(1) The positive drive shafting is geared to a positive drive rod which rotates the positive carbon continuously. On the positive drive shaft is a cam which is shaped so as to close the positive feed rate contacts each time it makes one revolution. These positive feed con-



- |  |  |
|--|--|
| 41. Elevation control motor.   | 82. Ventilating motor housing.   |
| 45. Arc view peep sight.   | 83. Transportation lock bar lug.   |
| 60. Ballast resistor.  | 84. Power cable receptacles.   |
| 67. Azimuth daylight sights.   | 85. Control station cable receptacle.  |
| 68. Lamp control mechanism box.  | 86. Sound locator cable receptacle. (Not part of the M-VI and M1934 lights since this cable goes to comparator directly on these models. The M-VI light has a white receptacle and a green receptacle at this location.) |
| 70. Recarboning lamp switch.   | 87. Signal buzzer. (Not part of the M-VI or M1934 lights.)   |
| 71. Elevation scale lamp.  | 88. Dynamotor (behind wheel). (For the M-VI light it is located at the power plant. For the M1934 unit it is located at the control station.)  |
| 72. Elevation scale.   | 89. Dynamotor pilot light.   |
| 73. Elevation gear sector.   | 90. Leveling jacks.  |
| 74. Meter box.   | 196. Recarboning safety switch. (Found only on the M1941 light.)   |
| 75. Hand controller socket.  |  |
| 76. Arc switch box.  |  |
| 77. Extension lamp receptacle.   |  |
| 78. Scale and meter light switch.  |  |
| 79. Azimuth lock.  |  |
| 80. Azimuth scale.   |  |
| 81. Azimuth data receiver housing. (Not part of M1934 and M-VI lights. M-VI light has a transmitter instead of a receiver at this location.) |  |

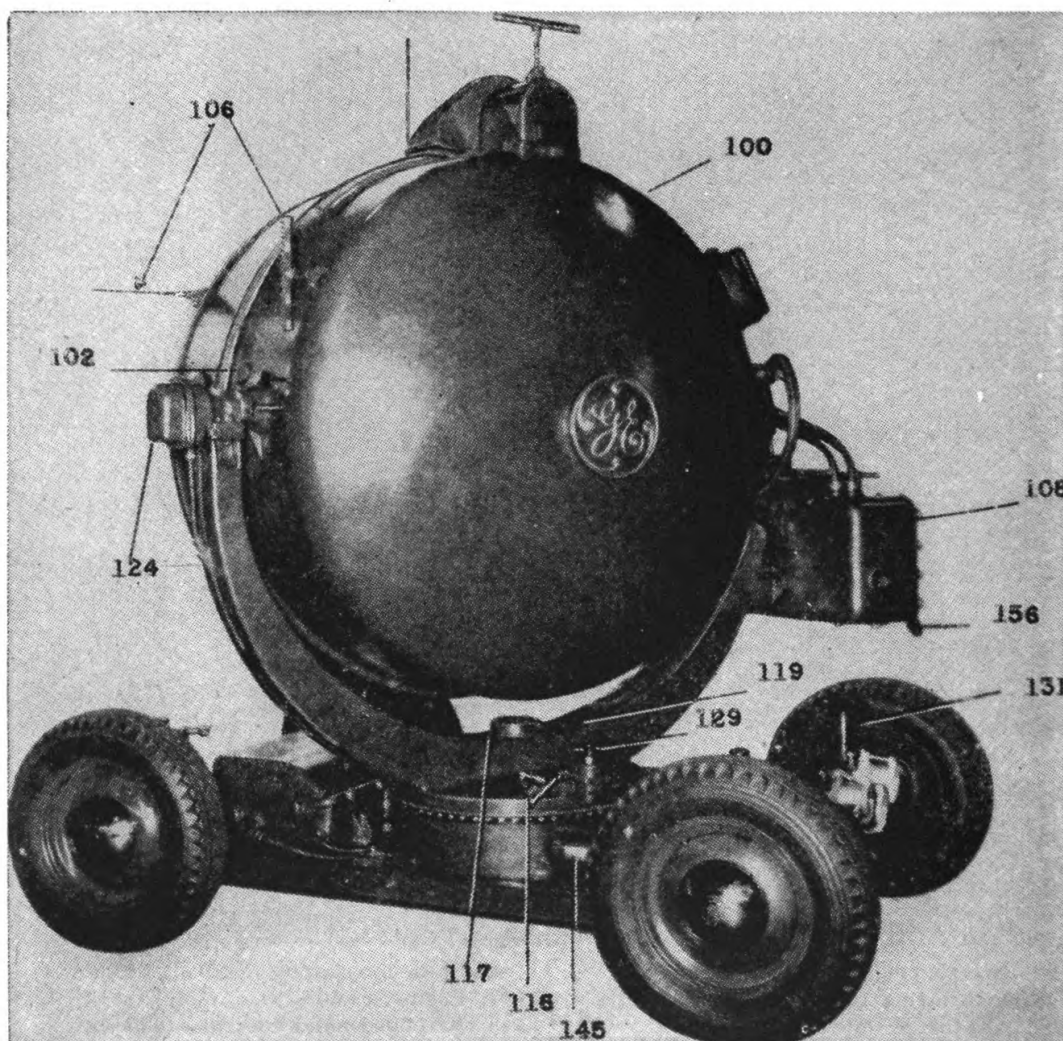
FIGURE 125.—Sperry M1941 AA searchlight (rear quarter view).



- |  |                                       |
|--|---------------------------------------|
| 102. Arc viewing window.                     | 144. Ballast resistor.                |
| 103. Ventilating fan and motor housing.      | 147. Focusing knob.                   |
| 104. Arc image screen.                       | 148. Extended hand control bar clamp. |
| 105. Daylight sights.                        | 149. Elevation scale lamp.            |
| 107. Lamp control mechanism box.             | 151. Drum access door.                |
| 109. Elevation brake handle.                 | 153. Elevation control box.           |
| 110. Extended hand control bar socket cover. | 154. Azimuth control box.             |
| 111. Recarboning lamp switch.                | 155. Azimuth scale.                   |
| 112. Scale lamp switch.                      | 156. Arc switch handle.               |
| 114. Azimuth scale lamp.                     | 157. Counterweight.                   |
| 127. Azimuth clutch switch.                  | 168. Glass.                           |
| 128. Dynamotor switch.                       | 200. Azimuth zero indicator.          |
| 130. Elevation stowing rod.                  | 201. Elevation zero indicator.        |
| 133. Towing bar.                             | 204. Arc ammeter.                     |
| 134. Junction box.                           | 205. Arc voltmeter.                   |
|  | 212. Dynamotor a-c indicating lamp.   |

FIGURE 126.—60-inch M1940 General Electric AA searchlight (front quarter view).

racts close a circuit, thereby energizing a positive carbon feed magnet which attracts a detent armature. Movement of the detent armature, through a rod, causes a detent to engage a detent gear on the positive head feed gear assembly. Attached to the detent gear is a spur gear. Both the detent gear and the spur gear are mounted on, and



- |                                 |                                     |
|---------------------------------|-------------------------------------|
| 100. Drum.                      | 119. Azimuth correction handle.     |
| 102. Arc viewing window.        | 124. Elevation data receiver cover. |
| 106. Elevation daylight sights. | 129. Azimuth stowing lock.          |
| 108. Elevation clutch switch.   | 131. Leveling jacks.                |
| 116. Levels.                    | 145. Dynamotor.                     |
| 117. Spindle cover.             | 156. Arc switch handle.             |

FIGURE 127.—60-inch M1940 General Electric AA searchlight (rear quarter view).

can rotate with respect to, the yoke. The exterior surface of the yoke serves as a shaft and bearing surface for the bearing of the detent gear and spur gear. When the detent gear stops, the spur gear stops. A planetary gear is mounted on, and rotates continuously with, the yoke. This planetary gear meshes with the spur gear which

is attached to the detent gear. When the detent and spur gears are stopped from rotating by the detent, the planetary gear "walks around" the spur gear, which causes, through shafting and gearing, the positive carbon feed rollers to drive the positive carbon forward. The length of time the positive carbon feed rate contacts are closed may be controlled by means of a positive carbon feed rate adjustment knob, thereby allowing the positive carbon to feed forward at the desired rate of feed.

(2) The negative drive shaft has a collar mounted on it. This collar is splined to the negative drive shaft so that it rotates, but it is free to slide along the shaft. On each end of this collar is a disk. The negative drive shaft and collar have a magnetic clutch built around them. This magnetic clutch has a forward feed coil around one end of the collar and a retract feed coil around the other end of the collar. When the forward feed coil is energized, the collar is moved so that the lower disk drives a friction-driven disk. This friction-driven disk rotates the negative drive rod and moves the negative carbon forward. When the retract coil is energized, the upper collar disk engages and causes the negative carbon to retract.

Q. Explain how the thermostat functions.—A. The thermostat, together with the regular positive feed, causes the positive crater to remain at the focal point of the mirror. It is mounted on the positive head. By means of a concave mirror, rays of light from the positive crater are focused on the thermostat. Within the thermostat are two bimetallic strips, each with contacts on its free end. When the light rays fall between the two, both are heated equally and neither moves with respect to the other. When the positive crater burns back, the light rays fall on the right bimetallic strip which warps so as to cause its contact to meet the contact of the left bimetallic strip. When these contacts meet, a circuit closes which energizes the positive carbon feed magnet, thereby feeding the positive carbon forward.

Q. There are two methods of energizing the positive carbon feed magnet. What are these two methods? A.—

(1) *Normal automatic positive carbon feed.*—When the positive carbon feed contacts are closed by the cam on the continuously rotating positive drive shaft, an electric current flows through this feed magnet and energizes it, thereby causing the positive carbon to feed forward.

(2) *By action of thermostat.*—When the positive carbon burns back  $\frac{1}{64}$  of an inch, the rays of light are focused on the thermostat causing its contacts to close before the positive crater burns back from the focal point more than  $\frac{1}{32}$  of an inch. When the thermostat contacts close an electric current flows through this feed magnet and energizes

it, thereby causing the positive carbon to feed forward to the focal point of the mirror.

*Q.* Can the positive carbon be fed backward as well as forward?—*A.* No. It feeds forward only.

*Q.* How does the negative feed control function?—*A.* The arc length is adjusted so that 150 amperes flow through it. It is a current-controlled arc. A coil in series with the arc energizes a current regulator. The current regulator closes contacts, thereby energizing either the negative forward feed coil or the negative retract feed coil. When the current drops below 150 amperes the forward feed coil is energized, thereby causing the arc to shorten and increase the current to 150 amperes. When the current increases above 150 amperes, the retract feed coil is energized and the arc is lengthened, the current decreasing to 150 amperes.

*Q.* Can the positive and negative carbons be fed other than by automatic feed control? Explain.—*A.* Yes. Either the positive or negative carbon may be operated manually. The positive carbon may be fed manually by means of the positive carbon manual drive crank by pushing it in and turning it clockwise. If it is necessary to feed the positive carbon forward rapidly, push in the positive carbon feed button in order to cause the detent to engage the positive head feed gearing. Manual feed of the positive carbon may be used whether the feed motor is running or not. The negative carbon may be fed or retracted manually by pushing in the negative carbon manual drive crank. Pushing the drive crank in opens the circuit of the magnetic clutch.

**135. Control stations (Sperry).—***Q.* For what purpose is a control station used?—*A.* To train the searchlight from a remote point in accordance with data sent from the sound locator.

*Q.* Of what does the control station consist?—*A.* The control station consists of a control unit and a tripod.

*Q.* Of what does the control unit consist on the M1937 to M1941 models?—*A.* It consists of the elevation control mechanism, the azimuth control mechanism, the binocular mount, and the azimuth and elevation zero reader indicators.

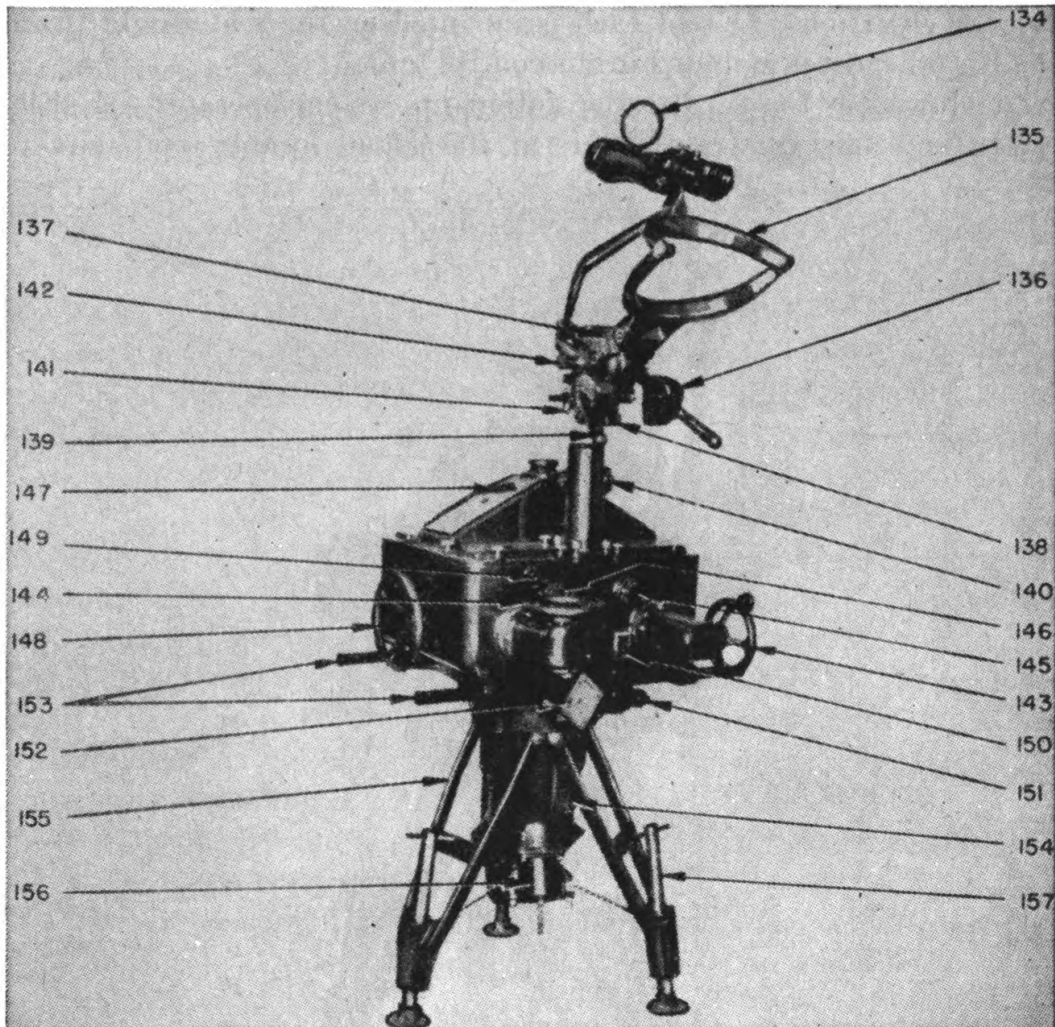
*Q.* Of what does the control unit consist on the M1934 unit?—*A.* It consists of the elevation control mechanism, the azimuth control mechanism, the binocular mount, a comparator for comparing sound locator data with the actual data set on the searchlight, and a mechanical oscillating mechanism for searching in a 5° spiral around sound locator data.

*Q.* Of what does the control unit consist on the M-VI model?—

1. It consists of the controller, which houses the azimuth and elevation

control mechanisms, and the comparator, which allows a comparison of sound locator data with the data set on the searchlight.

Q. How is the searchlight synchronized with the sound locator data?—A. Self-synchronous transmitters on the sound locator transmit electrically the angular movements of the sound locator to self-



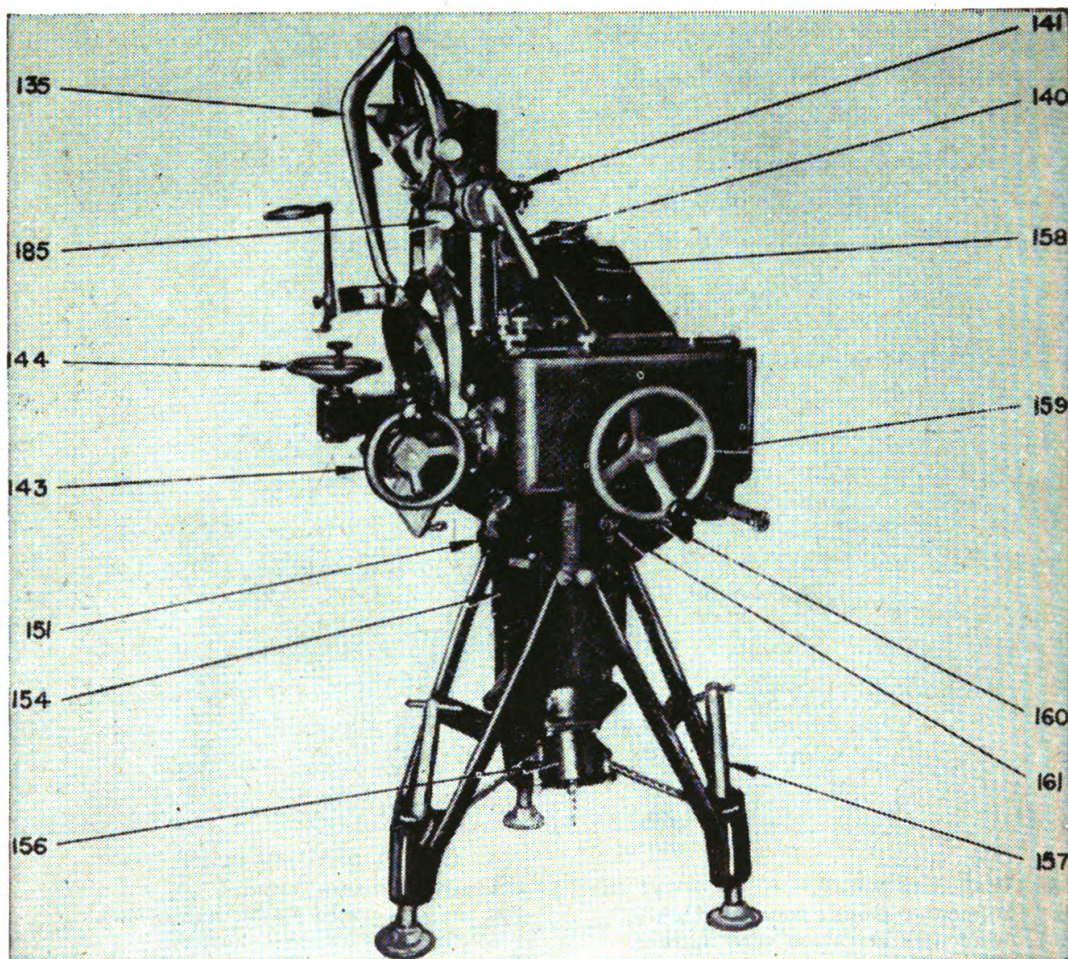
- |  |                                     |
|--|-------------------------------------|
| 134. Open sight.                         | 146. Azimuth drive slip clutch.     |
| 135. Binocular mount.                    | 147. Azimuth zero reader.           |
| 136. Binocular mount counterweights.     | 148. Azimuth zero reader handwheel. |
| 137. Binocular elevation zero marker.    | 149. Signal buzzer push button.     |
| 138. Binocular azimuth zero marker.      | 150. Zero reader light switch.      |
| 139. Binocular mount adjustment handles. | 151. D-c switch.                    |
| 140. Binocular height adjusting knob.    | 152. Alinement lug.                 |
| 141. Binocular mount azimuth adjustment. | 153. Carrying handles.              |
| 142. Binocular mount clutch adjustment.  | 154. Handhold cover plate.          |
| 143. Observer's elevation handwheel.     | 155. Tripod.                        |
| 144. Observer's azimuth handwheel.       | 156. Fifteen-point receptacle.      |
| 145. Elevation drive slip clutch.        | 157. Leveling jack.                 |

FIGURE 128.—Sperry M1941 control station (binocular mount in position).

NOTE.—The nomenclature of the M1937, M1939, and M1940 Sperry control stations is the same as the M1941 control station.

synchronous receivers. These are mounted and geared to the searchlight. The electrical output of the receivers goes to a phase-detecting circuit and from there to d-c, double-throw, zero-reading voltmeters. When the indicator on the zero-reading voltmeter is at the zero position, the searchlight is pointed or synchronized with the sound locator data. There are four zero-reading voltmeters, two for azimuth and two for elevation. One of each is mounted on the searchlight drum and the other set is mounted in the control unit.

*Q.* How does the zero reader follow-up system operate?—*A.* Elevation and azimuth transmitters at the sound locator send data to



- |   |                                       |
|---|---------------------------------------|
| 135. Binocular mount.                     | 156. Fifteen-point cable receptacle.  |
| 140. Binocular height adjusting knob.     | 157. Leveling jacks.                  |
| 141. Binocular mount azimuth slip clutch. | 158. Elevation zero reader.           |
| 143. Observer's elevation handwheel.      | 159. Elevation zero reader handwheel. |
| 144. Observer's azimuth handwheel.        | 160. Spirit levels.                   |
| 151. D-c switch.                          | 161. Clamp knob.                      |
| 154. Handhold cover plate.                | 185. Binocular mount locking pin.     |

FIGURE 129.—Sperry M1941 control station (binocular mount folded down).

NOTE.—The nomenclature of the M1937, M1939, and M1940 control stations is the same as the M1941 control station.

corresponding receivers mounted on the searchlight. The rotor of the elevation receiver (mounted on the left trunnion) is geared to the searchlight so that when the light elevates or depresses it causes the rotor to turn. The rotor of the azimuth receiver (mounted on the base of the trunnion arms casting) is geared to the searchlight so that when the light traverses right or left it causes the rotor to turn. When data is sent by the sound locator elevation (or azimuth) transmitter, a zero reader follow-up system electrically causes a pointer to move on a zero-reading d-c voltmeter. There are two zero-reading voltmeters for elevation, one mounted on the searchlight and the other on the control station. There are also two azimuth zero-reading voltmeters, one at the searchlight, the other at the control station. When, for example, new elevation data have been sent from the sound locator so as to increase elevation, the elevation zero-reading voltmeter pointers are deflected to the right of their zero (or center) positions. To cause these elevation pointers to go back to the zero position the elevation distant electric control zero reader handwheel must be turned counterclockwise so as to elevate the searchlight. As the searchlight is elevated it rotates the elevation receiver rotor which is geared to the searchlight. This rotation of the rotor causes the pointers of the elevation voltmeters to be moved toward the zero position. When the pointers reach the zero position (assuming sound locator, searchlight, and control station have been properly oriented), the searchlight has been elevated to the correct data as sent from the sound locator. The azimuth system operates in a similar manner.

*Q.* What switch must be turned on before using the D. E. C.?—*A.* The D. E. C. switch on the control unit.

*Q.* What type of distant electric control transmitters is used?—*A.* D-c step-by-step transmitters that operate on the same voltage as the arc.

*Q.* How many times does the azimuth D. E. C. transmitter rotate for one complete revolution of the control unit?—*A.* One hundred fifty times. For this reason, when the power is "off," be careful not to disturb the control station or the searchlight as it will throw the two out of orientation when power is put back "on." This also holds for elevation.

*Q.* Of what does the D. E. C. consist on M1934 to M1941 models?—*A.*—

(1) One azimuth D. E. C. transmitter and one elevation D. E. C. transmitter at the control station.

(2) Interconnecting circuits from the control station to the D. E. C. receivers at the searchlight.

(3) One azimuth receiver and one elevation receiver are located at the searchlight. These receivers are positioned by movement of their corresponding transmitters. The receivers are powerful enough to cause the searchlight, through shafting and gearing, to move in azimuth or elevation, thereby pointing the searchlight in the desired direction.

*Q.* Of what does the D. E. C. consist on the M-VI control station?  
*A.*—

(1) One azimuth D. E. C. transmitter and one elevation D. E. C. transmitter at the control station.

(2) Interconnecting circuits from the control station to the D. E. C. receivers at the searchlight.

(3) One azimuth receiver and one elevation receiver are located at the searchlight. Each receiver controls its respective training motor, so that when the receiver moves it causes the training motor to turn the light.

*Q.* How is the parallax between the searchlight and control station compensated for?—*A.* On control stations equipped with the binocular mount, the binocular mount may be adjusted in azimuth and elevation with reference to the control unit. The observer points on the desired part of the beam by manipulating the binocular mount adjustment handles.

**136. Control station (General Electric).**—*Q.* Does the General Electric control station differ greatly in appearance from the Sperry M1940 control station?—*A.* No. Outwardly, both are similar.

*Q.* For what purposes is the control station used? *A.*—

(1) To control the searchlight movements electrically from a remote point.

(2) To keep the searchlight in synchronization with sound locator data.

(3) To make the searchlight and binoculars search an area about the moving point established by sound locator data.

*Q.* What type zero-reading voltmeters are used for azimuth and elevation indicators?—*A.* These voltmeters are zero-reading a-c voltmeters.

*Q.* To what are these voltmeters electrically connected?—*A.* Through leads in a cable, the azimuth zero-reading voltmeter is connected directly to the sound locator data receiver rotor. This receiver is mounted in the base of the searchlight. In a similar manner, the elevation zero-reading voltmeter is connected to the elevation receiver rotor which is mounted on the left trunnion of the searchlight trunnion arms.

**Q.** Describe briefly how the zero reader indicator system functions.—**A.** This system is powered by 110-volt alternating current furnished by a rotary converter located on the searchlight. This indicator system has two a-c Selsyn transmitters (azimuth and elevation) at the sound locator connected by cable circuits to their respective receivers located on the searchlight. Azimuth and elevation receiver rotors are geared to the searchlight so as to be moved in azimuth and elevation, respectively, as the searchlight is trained. Electrically, the azimuth rotor is connected directly to two a-c zero-reading voltmeters, one mounted on the searchlight and the other on the control station. Similarly, the elevation receiver rotor is connected to two voltmeters, one at the searchlight and the other at the control station. Data sent from the sound locator causes the zero-reading voltmeter pointers to be deflected from their respective zero positions. By means of the distant electric control, the searchlight is traversed and moved in elevation. By moving the searchlight so as to agree with sound locator data, the receiver rotors move, thereby causing the pointers of the zero-reading voltmeters to move to their zero positions.

**Q.** What switches must be turned "on" before using the D. E. C.?—**A.** With the power plant delivering power to the searchlight, turn on the dynamotor switch at searchlight and the D. E. C. switch at the control station.

**Q.** What must be done in order to turn the control station in azimuth without disturbing the azimuth D. E. C. transmitter?—**A.** The azimuth clutch knob must be in the "release" position.

**Q.** How many synchronous positions may be had between the control station and the searchlight in azimuth? What precautions should be taken after orientation and synchronization?—**A.** Thirty-six. For this reason care must be exercised so that the control station, once oriented and synchronized with the searchlight, is not traversed when the D. E. C. power is "off." For a similar reason, the control station should not be elevated or depressed when the D. E. C. power is "off."

**Q.** Of what does the distant electric control consist?—**A.** It consists of the following main parts:

- (1) One Selsyn a-c azimuth transmitter and one Selsyn a-c elevation transmitter at the control station.
- (2) Interconnecting circuits from the control station to the D. E. C. receivers at the searchlight.
- (3) Two Selsyn a-c receivers, one azimuth and one elevation, located on the searchlight. A heart-shaped cam is mounted on each receiver rotor shaft. Each heart-shaped cam controls a series of

resistances in a Wheatstone bridge. Each bridge is connected to the armature of its corresponding training motor.

(4) Training motors are geared to the searchlight in azimuth and elevation.

(5) An electric antihunting device is a part of this system. It prevents the searchlight from "hunting."

*Q.* Explain briefly how the D. E. C. operates.—*A.* When the D. E. C. azimuth and elevation controllers rotate their respective handwheels, the D. E. C. azimuth selsyn transmitter rotors are turned accordingly. Since the transmitters are connected to the receivers, the receiver rotors will be moved correspondingly. This causes the heart-shaped cam to rotate, shorting out resistances in the Wheatstone bridge. This bridge is powered in such a manner that, as resistances are shorted out, the training motor armature (also connected across the bridge) has a current delivered to it. This causes the armature to rotate. By reversing the current through the armature the direction of rotation of the armature is changed. The direction of the flow of the current is controlled by the direction of rotation of the heart-shaped cam which shorts out the proper resistances.

*Q.* How is searching accomplished?—*A.* The zero reader voltmeters are used to accomplish oscillation in both elevation and azimuth. This is done by using the distant electric control handwheels so as to cause the pointers of the zero readers to move slowly right or left of the zero position. Limiting graduation marks to the right and left of the zero index have been placed on each zero reader. Moving the pointer of the zero reader so as to stay within these limiting graduations allows a search of  $5^{\circ}$  in any direction from the moving position of the target as given by sound locator data. The elevation distant electric control handwheel is geared to the binoculars so that the oscillating movement is applied directly to the binoculars in elevation. Turning the azimuth distant electric control handwheel moves the whole control unit in azimuth, and consequently the oscillation is applied in azimuth to both binoculars and the control unit upon which it is mounted.

**137. Power plants.**—*Q.* What is a rheostat?—*A.* It is a variable resistance which, when inserted in an electric circuit, can control the amount of current which will flow.

*Q.* Explain how a rheostat is used on the searchlight power plants.—*A.* By placing a rheostat in the field circuit of the generator, the amount of exciting current flowing in this circuit can be controlled. This exciting current energizes the electromagnets of the generator field. The more current that flows, the stronger the electromagnets, thereby causing an increase of generated voltage. Decreases

ing the exciting current decreases the generated voltage. By varying the resistance of the rheostat the voltage of the generator may be regulated.

*Q.* What is the purpose of placing fuses in an electric circuit?—

*A.* Fuses are made of wire which will conduct currents of a given amount through them but which will immediately heat and melt, breaking the circuit, when the current increases beyond its rated current-carrying capacity. Fuses are used to protect delicate electrical instruments or expensive parts of an electrical system.

*Q.* What other type of interrupter is used by the searchlight unit?—*A.* Circuit breaker.

*Q.* Briefly explain how a circuit breaker operates.—*A.* There are many kinds of circuit breakers. Some are controlled magnetically, some by heat, and others by a combination of heat and a magnetic field. Some are adjustable for different current ratings; others are built for but one current rating. When a current larger than the current rating for that particular circuit breaker flows through it, the breaker opens the circuit so as to prevent damage to the equipment.

*Q.* Can a person be injured by improper maintenance or operation of searchlight equipment?—*A.* Yes. A person can be killed.

*Q.* What precautions should be taken to prevent injury?—*A.* Always be certain that the power plant main switch is "off" when maintenance work is done on the searchlight. Always be certain the power plant is not running when performing the normal power plant maintenance work. Repairs of an electrical nature should be made by the electrical sergeant attached to the platoon. An operator should know where his current comes from and where it goes—in other words he should know how to trace the electrical circuits on the equipment. This will not only make him more efficient but will prevent his sustaining injuries or burns by touching a live lead at some exposed point.

*Q.* Describe the power plant with which your searchlight is powered.—*A.* (1) *M1941, M1940, M1939, and M1937 power plants (Sperry).*—Each unit is a complete power plant consisting of a gasoline engine directly connected to a d-c generator, control equipment and power panel, and the chassis and housing.

(a) The power plant is equipped with standard automobile wheels and tires and can be towed by a truck for short distances over good roads. On long hauls it is transported in a truck or trailer.

(b) The engines are Hercules JXD, six-cylinder, with one spark plug per cylinder. They are equipped with engine accessories found

commonly on all gasoline engines, including radiator, distributor, generator, ignition coil, starting motor, and battery. The engines are equipped with governors to control engine speed as follows:

| Model | Rpm           |                |
|-------|---------------|----------------|
|       | Arc load "on" | Arc load "off" |
| M1941 | 1, 100        | 1, 150         |
| M1940 | 1, 000        | 1, 050         |
| M1939 | 1, 200        | 875-900        |
| M1937 | 1, 200        | 875-900        |

(c) The d-c generators are rated as follows:

|                           | Make and model                         |  |  |   |
|---------------------------|--|--|--|---|
|                           | Westinghouse<br>SK 90 Special<br>M1941 | Westinghouse<br>SK 93 Special<br>M1940 | Westinghouse<br>SK 93 Special<br>M1939 | General Elec-<br>tric Type<br>CT-1501-EI<br>M1937 |
| Rpm:                      |  |  |  |   |
| Arc load "off"            | 1, 150                                 | 1, 050                                 | 875-900                                | 875-900   |
| Arc load "on"             | 1, 100                                 | 1, 000                                 | 1, 200                                 | 1, 200  |
| Volts (arc "on" or "off") | 100                                    | 100                                    | 100                                    | 100   |
| Amperes:                  |  |  |  |   |
| Arc load "off"            | 12                                     | 12                                     | 15                                     | 15  |
| Arc load "on"             | 162                                    | 162                                    | 165                                    | 165   |
| Kilowatts output          | 16. 2                                  | 16. 2                                  | 16. 5                                  | 16. 5   |

(d) The engine and generator may be completely controlled from the power panel. Control is automatic, but provision is made for hand control.

(2) *M1940 power plant (General Electric).*—The General Electric power plant consists of—

(a) A gasoline engine and auxiliaries, including radiator, fan, and governor for control of engine speed, having the following characteristics:

1. The engine is a Hercules JXD, 6-cylinder, with one spark plug per cylinder.
2. It has a force feed system of lubrication and an oil filter.
3. It is equipped with a governor to control engine speed at 1,200 rpm.

4. It is equipped with engine accessories found commonly on all gasoline engines, including radiator, distributor, generator, ignition coil, starting motor, and battery.

(b) A d-c generator direct-connected to the engine with four main and two commutating poles, weighing 650 pounds, and having the following electrical characteristics:

|                                      | <i>Volts</i> | <i>Amperes</i> | <i>Rpm</i> | <i>Kilowatts</i> |
|--------------------------------------|--------------|----------------|------------|------------------|
| Arc load "off" (listening load)----- | 100          | 8              | 1,200      | 0.8              |
| Arc load "on"-----                   | 100          | 160            | 1,200      | 16.0             |

(c) A control panel on which are mounted—

1. Power-indicating instruments.
2. Power main switch.
3. Field rheostat.
4. Tachometer (to indicate engine speed).
5. Engine indicators, to include a temperature indicator and an oil pressure gage.
6. Lighting facilities.

(d) Suitable chassis and housing for military purposes. Standard automobile wheels and tires are used. The power plant may be towed by a truck for short distances over good roads.

(3) *M1934 portable power plant (Sperry).*—The M1934 portable power plant is a complete portable unit mounted on chassis provided with four small, steel wheels. This unit can be moved for short distances over hard surfaces. For long hauls this unit is transported on a portable equipment trailer.

(a) The generator is a 31.25 kilowatt, 125-volt, 250-ampere, 1,400-rpm, differential compound generator, directly coupled to the engine. It supplies power for the arc as follows:

|                                      | <i>Volts</i> | <i>Amperes</i> | <i>Rpm</i> |
|--------------------------------------|--------------|----------------|------------|
| Arm load "on"-----                   | 100          | 165            | 1,200      |
| Arc load "off" (listening load)----- | 102          | 15             | 850        |

(b) The control panel or switchboard is mounted on the rear end of the power plant, and contains the following main units:

1. Circuit breaker for the arc load.
2. Load-setting switch, which is used to select 150-, 200-, or 250-ampere load.
3. Voltage manual rheostat, which is used to adjust the voltage when using manual control.
4. Voltage automatic rheostat, which provides a fine adjustment of voltage when generator is on automatic operation.
5. D-c load ammeter.

6. D-c generator voltmeter.

7. Tachometer.

(c) The control of the power unit is fully automatic. If desired, it may be manually controlled.

(d) The engine is a Hercules model WXC-3, six-cylinder gasoline engine and has both battery and magneto ignition with two spark plugs per cylinder.

(4) *M1934 mobile power plant (Sperry).*—The M1934 power plant utilizes the engine of the Duplex truck for driving the generator. The vehicle engine is a 6-cylinder General Motors engine, delivering 112.5 horsepower at 2,800 rpm.

(a) The generator is a d-c commutating pole type with self-excited shunt wound fields mounted in rear of the transmission. The voltage of the generator is controlled by an automatic regulator. The speed of the engine and generator is controlled by a mechanical governor driven by, and located on, the engine. With certain minor adjustments the generator supplies power for the arc under the following conditions:

|                                      | <i>Volts</i> | <i>Amperes</i> | <i>Rpm</i> |
|--------------------------------------|--------------|----------------|------------|
| Arc load "on"-----                   | 98           | 165            | 1,100      |
| Arc load "off" (listening load)----- | 101          | 15             | 900        |

(b) The control panel is mounted directly behind the driver's seat. The panel contains the necessary control apparatus to adjust and maintain constant voltage. There are in addition necessary protective devices such as relays, instruments, and resistors. The front of the control panel contains the following:

1. D-c voltmeter.
2. D-c ammeter.
3. Rheostat to select and adjust the voltage.
4. Circuit breaker for the searchlight current.

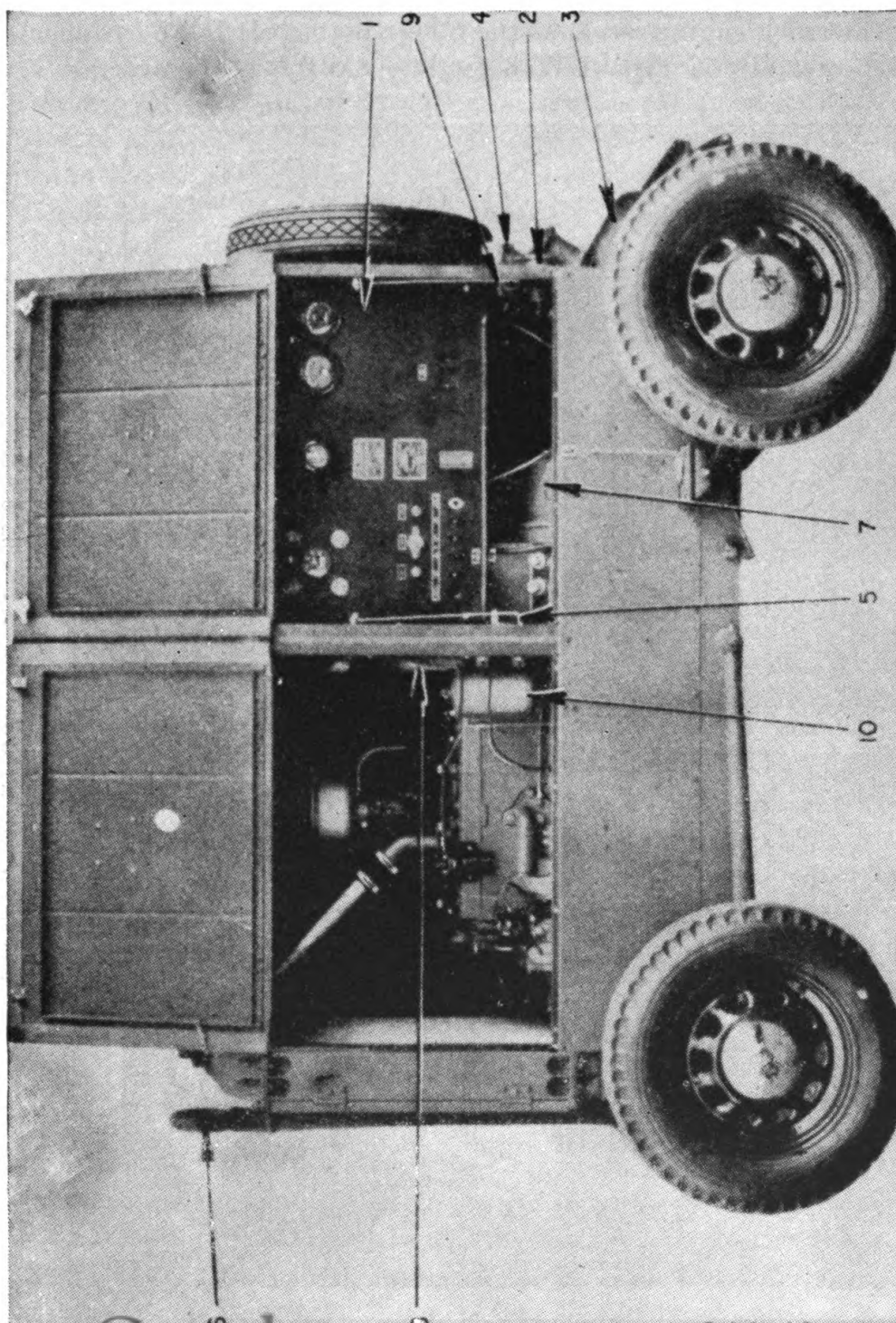
(c) The rotary converter is a portable unit and is usually placed near the control station.

(5) *MVI power plant (Sperry).*—(a) A Duplex truck transports the searchlight and furnishes the power for operation of the searchlight.

(b) A 15-kilowatt flat compounded d-c generator, designed to deliver 150 amperes at 100 volts with an engine speed of 1,800 rpm, is mounted on the chassis in rear of the transmission. A hand clutch is located in the cab so that the tail shaft may engage and operate the d-c generator or the rear axle.

(c) The power panel is mounted directly behind the driver's seat and includes the following:

1. Circuit breakers for the searchlight current.
2. Field rheostat for adjusting the voltage.
3. D-c voltmeter.
4. D-c ammeter.



1. Control panel.
2. Power receptacles.
3. Fuel tank.
4. Tail lamp.
5. Control panel door bracket.
6. Tow bar.
7. Power generator.
8. Fan.
9. Tail lamp switch.
10. Oil filter.

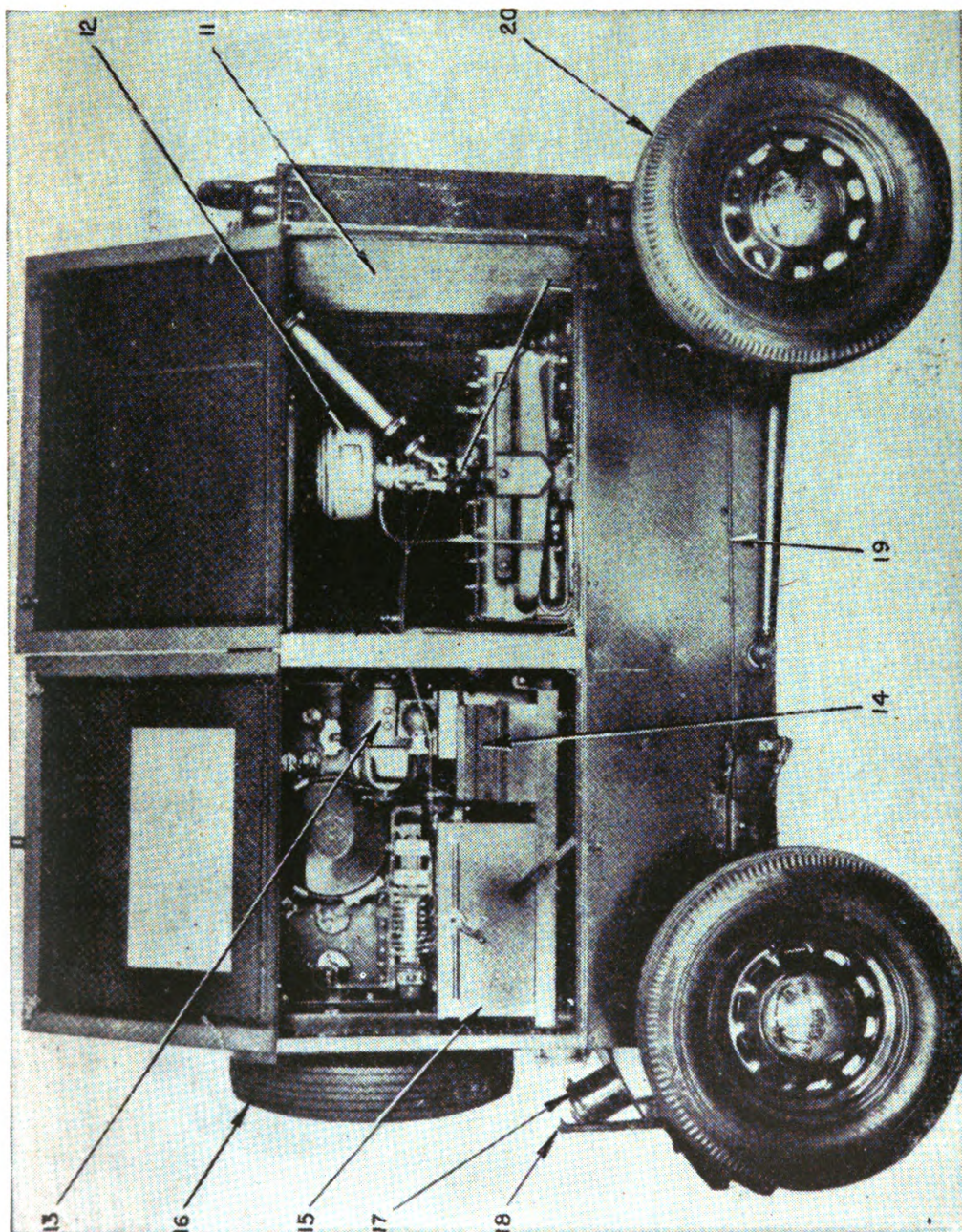
FIGURE 130.—Sperry M1941 power plant (left side).

5. A-c voltmeter to indicate a-c voltage from rotary converter.

6. A switch for starting the rotary converter.

(d) A  $\frac{3}{4}$ -kva, 3,600-rpm, 60-cycle, single-phase rotary converter is mounted on the right-hand running board. It converts 100 volts direct current from the searchlight generator into 120 volts alternating current (used with AA searchlights for the a-c data transmission system employed by the comparator).

(e) The truck engine serves as the power plant. It is a 6-cylinder, 55-horsepower, Buda type DW-6 engine. A flywheel governor is



- |                 |                               |
|-----------------|-------------------------------|
| 11. Radiator.   | 19. Safety chain brake cable. |
| 12. Air filter. | 20. Exhaust.                  |
| 13. Fan motor.  |                               |
| 14. Battery.    |                               |
|                 | 15. Tool box.                 |
|                 | 16. Spare wheel and tire.     |
|                 | 17. Fuel tank filler pipe.    |
|                 | 18. Brake lever.              |

FIGURE 131.—Sperry M1941 power plant (right side).

provided for maintaining an engine speed of 1,800 rpm when driving the generator.

**138. Orientation and synchronization.**—*Q.* Briefly describe how a searchlight unit is oriented and synchronized.—*A.* Level the searchlight, sound locator, and control station. Two methods commonly used are—

(1) Direct the sights of the sound locator, searchlight, and control station at a star (or distant point) and set all azimuth scales and indicators to zero. For units equipped with the zero reader, set the zero reader pointers to the zero position. In units equipped with the M-VI control station, point control stations in the same general direction as the searchlight and sound locator. For elevation, set sound locator, searchlight, and control station binoculars to zero elevation, then cause all indicators to indicate zero elevation.

(2) Direct the sights of the sound locator and searchlight on each other. Then set the sound locator azimuth scale to zero and the searchlight scale to 180° (or 3,200 mils). Traverse searchlight to zero azimuth and set all azimuth indicators (zero reader's also) to zero. Point the searchlight by its sights on the control station and backsight the control station on the searchlight by pointing the large end of the binoculars at the center of the searchlight drum. For elevation, proceed as in (1) above.

*Q.* Where can detailed instructions be found for orienting and synchronizing the searchlight?—*A.* In operator's manual furnished with the equipment.

**139. Maintenance, care, and adjustment of parts.**—*Q.* Where can full instructions covering maintenance, care, and adjustment of the searchlight unit equipment be found?—*A.* This information is found in the operator's manual issued with the equipment. *These instructions should be followed exactly.*

*Q.* What is the chief responsibility of the searchlight lamp operator?—*A.* To see that the carbons are properly placed at all times and are functioning properly. Failure to do this will cause burning of the positive or negative head which, in turn, will drop hot metal on the mirror, thereby damaging it.

*Q.* What care should be taken of the generator?—*A.* The generator must be carefully watched while in operation. The ventilating system must be carefully checked to see that it is operating correctly. Excessive sparking should be reported to the section leader or maintenance sergeant who will supervise cleaning of the commutator bars.

*Q.* Should the generator be oiled?—*A.* Yes. But only at the points indicated by oil cups or grease receptacles. Grease on the commutator bars or other electrical contact points should be avoided.

*Q.* How should carbons be stored?—*A.* In a cool, dry place and if possible in the original container until ready for use.

*Q.* What care should be taken of the lamp mechanism?—*A.* It should be properly cleaned and lubricated at all times. Care should be taken not to permit grease to collect around the contact elements as this will impair the contacts of the brushes and cause faulty functioning.

*Q.* How should electric cables be handled so that they are not damaged?—*A.* Cables should be carried by the crew and not dragged along the ground. Especially the plug couplings should not be dragged. These are made of aluminum alloy and when they are dragged along the ground in winding cable they become distorted in shape and will not fit properly in the receptacle. Also, each contact is connected within the plug to a small lead of the cable. Dragging will cause breaking of these small conductor leads, thus interrupting the system. No pulling strain should ever be applied on cables while removing plugs. Take hold of the plug itself and pull it out.

*Q.* What are some general rules pertaining to loading and unloading the searchlight?—*A.* Do not use excessive speed in loading or unloading. Never force the searchlight into position in the vehicle. Seek out the cause of the interference and remove it. Be sure that the bows do not interfere when loading and unloading the searchlight. Do not leave a long positive carbon in the searchlight when loading it. The carbon will probably break off and may drop on the front door window, breaking the glass.

## SECTION II

### TROUBLES AND REMEDIES

|                              | Paragraph |
|------------------------------|-----------|
| Circuits.....                | 140       |
| Lamps .....                  | 141       |
| Switches .....               | 142       |
| Ammeters and voltmeters..... | 143       |
| Miscellaneous .....          | 144       |

**140. Circuits.**—*Q.* What instruments are used for making ordinary tests of defective circuits in searchlight matériel?—*A.* A voltmeter can be used and all searchlights should be provided with test lamps, consisting of an incandescent globe with two insulated leads projecting from the socket containing the globe. With power on the circuit, the live lines can be tested with this light. For testing for faults in circuits where no power is applied during the test, a voltmeter, telephone receiver, or buzzer, with a battery in series, may

be used. Numerous variations of the above method may be improvised.

*Q.* What are the chief sources of trouble in d-c electrical systems?—*A.* Open circuits, short circuits, and grounds.

*Q.* How is the test for each made? *A.*—

(1) *Open circuits.*—Complete a known circuit by wiring together any open leads, for instance the positive and negative power leads in a nine-conductor cable. Locate the other ends of the two leads and test across these two with the buzzer arrangement described above. If the circuit is complete there will be a buzz or click. If no impulse is received the circuit is open.

(2) *Short circuits.*—Be sure that the two lines being tested are not connected so that there is no completed circuit through them normally. Test at several places along the cable and if there is a short circuit some place in the line there will be a completed circuit through the test set.

(3) *Grounds.*—Connect one terminal of the test set to a live lead. The other terminal of the test set should then touch the frame of the searchlight or instrument where a ground is suspected. If there is a ground in the circuit an impulse will be received in the test set. If the line is clear there will be no sound.

**141. Lamps.**—*Q.* Power on the system of an electrically controlled searchlight is indicated by the glow of the incandescent bulbs at various points of the system. If an incandescent lamp goes out, what does this indicate and what is the remedy?—*A.* Usually this indicates a blown fuse. Examine the fuse with a test lamp but do not replace it without first attempting to discover the cause of the excessive current. This trouble may also be caused by open circuits, loose or broken contacts, or burned-out bulbs.

*Q.* What are some of the causes of lamps becoming dim during operation of the searchlight? *A.*—

- (1) Wire connections to the switch defective.
- (2) Lamp socket terminal loose.
- (3) Halves of the connectors not making good contact.
- (4) Defective connections at the lamp.
- (5) Fluctuations in the voltage.

*Q.* What causes lamps to flicker? *A.*—

- (1) Loose connections.
- (2) Voltage fluctuations.
- (3) Intermittent short circuits.

*Q.* In the automatic control searchlights, how are the functions of the various searchlight mechanisms tested prior to actually starting the arc?—*A.* With no carbons in place, apply the supply volt-

age to the searchlights for a brief period and check up on the operation of the fan motor and positive and negative feed mechanisms. Operation of the feed motor should cause the positive and negative mechanisms to rotate in the proper directions.

*Q.* After the arc current has been supplied and the arc starts burning, what is the first thing the operator should do?—*A.* Check up on the voltage. The voltage is indicated on the meter at the searchlight and should be 78 to 80 volts with a current of approximately 150 amperes.

*Q.* What is the maximum voltage permitted at the generator terminals, as indicated on the voltmeter at the power plant?—*A.* One hundred and twenty volts. The voltage should be regulated within 5 volts of 100 at all times by use of the field rheostat.

*Q.* When the arc is struck, what does the lamp operator do if the negative feed does not move the carbon back properly from the positive?—*A.* First, shift the centralizing knob from "auto" to "hand". Then move the negative carbon back by the negative feed knob. Do not use the arc-regulating mechanism to adjust the position of the negative carbon until the light has been burning for several minutes.

*Q.* What should be done with respect to the positive carbon?—*A.* Check to be sure that it is rotating properly and that it is at the proper point with respect to the positive head. The crater of the positive carbon should normally be  $1\frac{1}{16}$ -inch in front of the positive head nose.

*Q.* How are hand adjustments of the positive carbon made?—*A.* By means of the positive hand feed knob. It can be fed forward only.

**142. Switches.**—*Q.* Where is the main switch at the searchlight?—*A.* On the later model searchlight the switch is on the trunnion arm. On other models the switch is on a terminal box mounted on one axle.

*Q.* Point out the switches on the searchlight in use by the organization (candidate's) and tell what each is for.—*A.* (Practical demonstration.)

*Q.* What general care should be given to switches? *A.*—

(1) They should be examined frequently to see that the blades seat properly.

(2) All leads should be tightly connected.

(3) All contact surfaces should be kept free from grease and dirt at all times.

(4) The switches must be thrown and released quickly to prevent arcing. Arcing will fuse some of the copper and roughen the contact surface.

(5) All fused metal should be filed off.

**143. Ammeters and voltmeters.**—*Q.* What care should be given to voltmeters and ammeters?—*A.* They should be protected from jars. If the indicator needle in an instrument sticks, tap the instrument case gently. If it fails to respond to this treatment, do not try to repair it in the field. A voltmeter or ammeter is a delicate instrument and must be carefully calibrated during the process of readjustment.

*Q.* How should ammeters be connected in a circuit?—*A.* In series with the line.

*Q.* How should voltmeters be connected in a circuit?—*A.* Across the line.

**144. Miscellaneous.**—*Q.* Name some of the causes which necessitate removing and cleaning the generator brushes. *A.*—

(1) If the ventilating windows of the generator are left open during road travel, dust, dirt, and dampness will enter and corrode both the brushes and commutator. In this case it will be necessary to remove the brushes and clean the contact surfaces. The commutator likewise should be cleaned.

(2) Sometimes the brushes wear unevenly or the commutator becomes rough in ordinary usage. The brushes should be removed as soon as this is detected and new ones inserted in their places. The old brushes may later be reground and used as spares. The commutator may be smoothed out by using light sandpaper, but care must be taken not to cut too much from the surface and not to fill up the insulation gap between the bars with sand dust. Under no circumstances should a metallic or emery cutter be used on the commutator.

(3) If oil accumulates on the contact surfaces of the brushes or on the commutator, the functioning of the generator will not be satisfactory and the commutator and brushes should be thoroughly cleaned.

*Q.* How should all clearances between electric contact points be set?—*A.* Usually with micrometer tools. In adjusting the distant electric control the instructions in the book furnished with the unit should be carefully followed. All other adjustments should be made according to instructions in the pamphlets issued.

*Q.* In dismantling equipment what precautions should be taken to prevent loss of parts?—*A.* A canvas or box should be made available so that the parts may be placed therein immediately on removal. Retaining screws and washers may be replaced in their threads for safekeeping. Care should be taken to keep the parts clean after their removal and they should be wiped off before being replaced.

*Q.* In general, what "trouble shooting" should a chief of section be prepared to do?—*A.* He should be able to locate and repair minor troubles and keep the system in operation under ordinary conditions.

He should have enough knowledge to protect the equipment from extensive damage, determine the apparatus at fault, and be able to assist the electrician sergeant in locating trouble and making repairs to the electrical equipment.

## SECTION III

## SOUND LOCATOR APPARATUS

|   | Paragraph |
|---|-----------|
| General.....                                    | 145       |
| Sound locator apparatus.....                    | 146       |
| Sound locators.....                             | 147       |
| Acoustic correctors.....                        | 148       |
| Maintenance, care, and adjustment of parts..... | 149       |

**145. General.**—*a.* A successful method of detection of enemy aircraft at night is by means of the sound coming from the aircraft. As an aid to ears, sound locators are used. Persons having normal hearing can detect the direction from which a sound comes. This sense of determining direction of a source of sound is called the binaural sense. It depends upon the fact that the ears can detect the very small difference in time between the time the ear closer to the sound source hears it and the time the other ear hears it. To aid binaural sense, the distance between the ears is increased by the use of horns, a distance of 60 inches between horns giving excellent results. The horn also intensifies the sound, its action being similar to that of placing the cupped hand behind the ear as an aid.

*b.* Since sound takes an appreciable amount of time to travel through air (approximately 1,100 feet per second), the airplane will travel during this "sound lag" interval. Consequently there should be a sound lag correction applied to the apparent source of sound determined by the sound locator, an acoustic corrector being used to make this sound lag correction.

*c.* Sound locators now in service are either of the M1 or M2 series. The particular models of trailer and corrector which make up the sound locators, M1 series, are tabulated below. The horns and horn mounts are essentially alike in this series, differing only in details of manufacture.

|                    |      |      |      |      |      |      |      |      |
|--------------------|------|------|------|------|------|------|------|------|
| Sound locator..... | M1A1 | M1A2 | M1A3 | M1A4 | M1A5 | M1A6 | M1A7 | M1A8 |
| Trailer.....       | M2   | M2A1 | M2A2 | M2A3 | M2A2 | M2A3 | M3   | M2A4 |
| Corrector.....     | M1   | M1   | M1   | M1   | M1A2 | M1A1 | M2   | M2   |

The M2 sound locator is the latest type in use by our service. It is portable, breaking down into six component parts for transportation. It employs a new type of acoustic corrector which is much more efficient than that in the M1 series.

**146. Sound locator apparatus.**—*Q.* What is the speed of sound in air?—*A.* It is approximately 1,100 feet per second.

*Q.* If the distance from a sound locator to a sound source is 11,000 feet, how long will it take for the sound to reach the sound locator?—

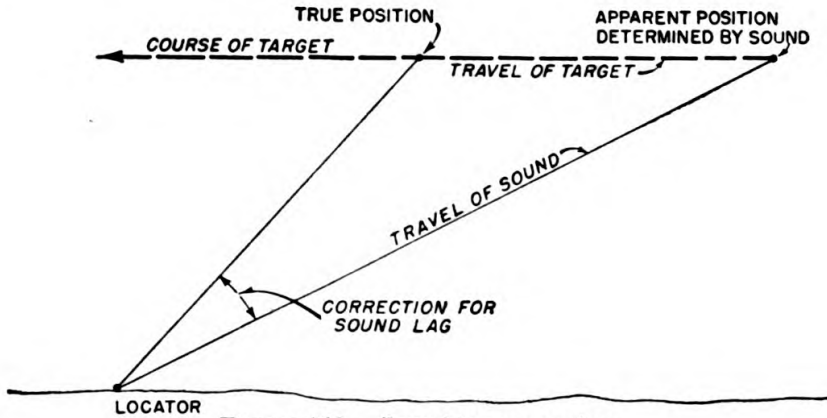
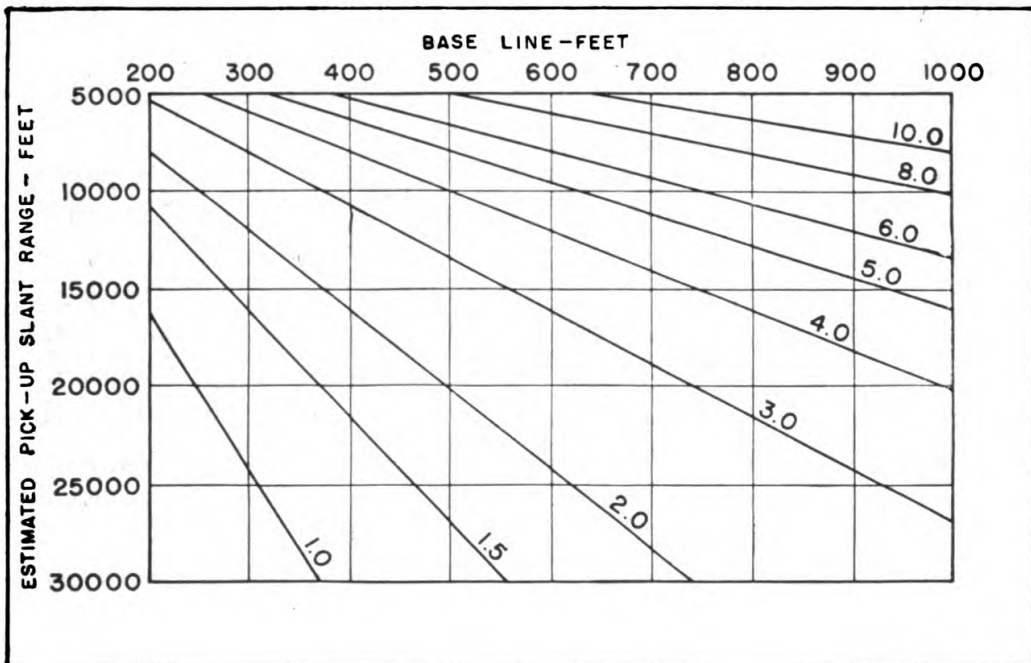


FIGURE 132.—Sound lag correction.

*A.* Ten seconds. By the time the sound has arrived at the sound locator the plane has moved to its true position.

*Q.* What is this time interval called?—*A.* The sound lag interval.



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FIGURE 133.—Graph of parallax settings.

*Q.* What effect does wind have on sound?—*A.* It has the effect of apparently displacing the sound source in the direction the wind is going.

**Q.** Is there any error introduced by placing the searchlight some distance away from the sound locator?—**A.** Yes. This introduces a parallax error for which a correction must be made.

**Q.** Will the searchlight always pick up the target immediately after the sound lag, wind, and parallax corrections are applied?—**A.** No. Atmospheric conditions change continuously causing slight errors. These errors, with well-trained personnel, are not over 5°. For this reason searchlight control stations are designed to allow for a 5° search around the sound locator data.

**Q.** How are sound locator operators chosen?—**A.** The men who are best suited for this work should be selected from battery personnel on the following basis:

- (1) Desire to become a sound locator operator.
- (2) Patience and attentiveness.
- (3) Acuity of hearing.

Usually people living in a noisy city do not have the acuity of hearing of those who live in quiet places. To be certain a person has the necessary acuity of hearing he should be given a test, preferably by a medical officer.

**147. Sound locators.**—**Q.** What is the approximate weight of the M1 series sound locator and trailer?—**A.** Approximately 2¾ tons.

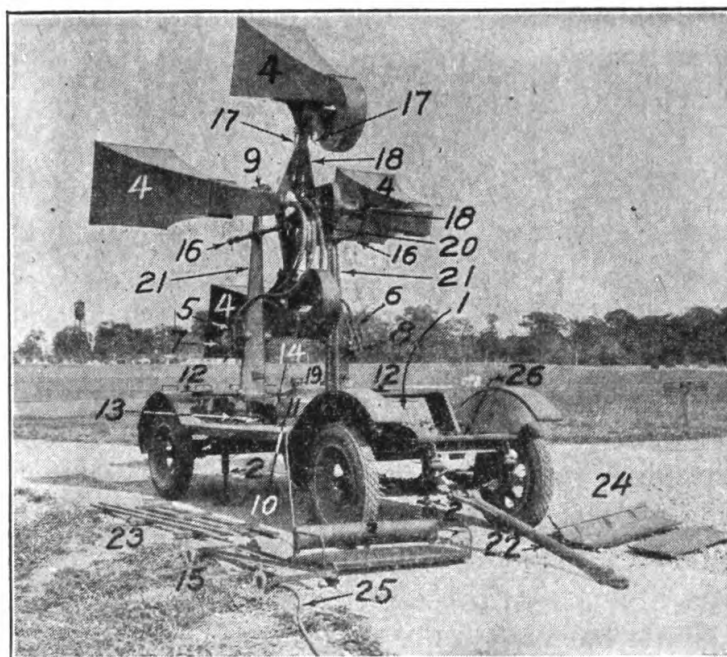
**Q.** Describe the horns used on the M1 series sound locator.—**A.** Four metal horns are used, two for azimuth and two for elevation. The distance from center to center of a pair of horns is approximately 111 inches. Horns must be removed from their operating position to their traveling position supports before the sound locator is ready for the road.

**Q.** How is the M1 series sound locator put in the operating position?—**A.** Jack up the trailer and level the sound locator turntable by means of the four jacks suspended from the frame. Jacks must be held rigidly in position by the retaining pins provided. Two leveling jacks on the turntable are used in leveling the sound locator. Horns must be removed from traveling supports and be placed on operating supports.

**Q.** What is the total traveling weight of the M2 series sound locator?—**A.** The total traveling weight, including cable and cable reel, is slightly over ½ ton.

**Q.** Describe the horns used on the M2 sound locator.—**A.** Three horns are used. A common horn with a split sound track serves a dual purpose, being used for both azimuth and elevation. Different materials are used in the horns so as to reduce unnecessary noise. Horns are 60 inches apart, vertically and laterally.

Q. How has the M2 series sound locator been made more efficient than the older models?—A. By better construction, thereby decreasing noise caused by the moving parts, and by using a horn which is directional, thereby eliminating all noise except in the direction of the target. The horns pick up and intensify all sounds  $15^{\circ}$  on either side of the center line of the horn.



- |                          |                                    |
|--------------------------|------------------------------------|
| 1. Sound lag corrector.  | 14. Adjustable locking screws.     |
| 2. Jacks.                | 15. Horn locking frame (removed).  |
| 3. Front seat (removed). | 16. Traveling horn supports.       |
| 4. Horns.                | 17. Hand clamp screws.             |
| 5. Traversing handwheel. | 18. Horn support sections.         |
| 6. Elevating handwheel.  | 19. Elevation control shaft.       |
| 7. Headset (azimuth).    | 20. Rubber tubes.                  |
| 8. Headset (elevation).  | 21. Vertical columns.              |
| 9. Horn bearings.        | 22. Towing bar.                    |
| 10. Azimuth circle.      | 23. Side frames.                   |
| 11. Turntable.           | 24. Covers for acoustic corrector. |
| 12. Seats for operators. | 25. Cable leading to comparator.   |
| 13. Footrest.            | 26. Brake handle.                  |

FIGURE 134.—Sound locator M1A1.

Q. What precautions in regard to noise should be taken by the operating personnel of the sound locator?—A. Operators should work with a minimum of noise. Sound discipline must be strictly enforced in the vicinity of the sound locator.

Q. Of what does the acoustical system for both the M1 and M2 series consist?—A. It consists of horns, sound-conducting tubing, and listener's helmets.

Q. What are the six component parts for transportation of the M2 series sound locator? A.—

|  | Lbs.  |
|--|-------|
| (1) Two horn assembly with horn covers-----                    | 114   |
| (2) Single horn assembly-----                                  | 67    |
| (3) Corrector assembly with carrying case and spare parts----- | 330   |
| (4) Column-----  | 30    |
| (5) Platform-----  | 130   |
| (6) Cable and cable reels-----                                 | 395   |
| Total-----   | 1,066 |

Q. How are the component parts of the M2 sound locator assembled? A.—

- (1) Place platform on firm footing and level it approximately.
- (2) Place column on platform and bolt it down.
- (3) Place corrector assembly on column. *Be certain that the cable plug is dropped down through the column first.* Bolt assembly in place. Place plug in bracket mounted under platform. Remove transportation bracket from assembly.
- (4) Elevate to maximum elevation and tighten in place by elevation clamp.
- (5) Bolt single horn assembly in place; then bolt the double horn assembly in place. *Keep canvas covers on horns while assembling.* Remove all covers after horns are in place.
- (6) Mount pantograph on the drive case.
- (7) Connect cable to receptacle plug.
- (8) Level whole unit by means of level bubble mounted on corrector assembly.

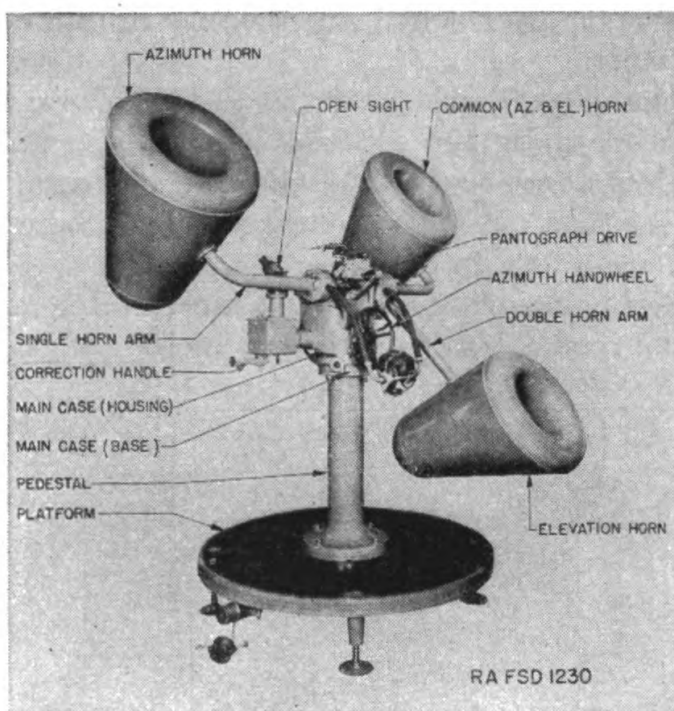
148. **Acoustic correctors.**—Q. What three corrections are acoustic correctors designed to make? A.—

- (1) Sound lag correction.
- (2) Wind correction.
- (3) Parallax corrections.

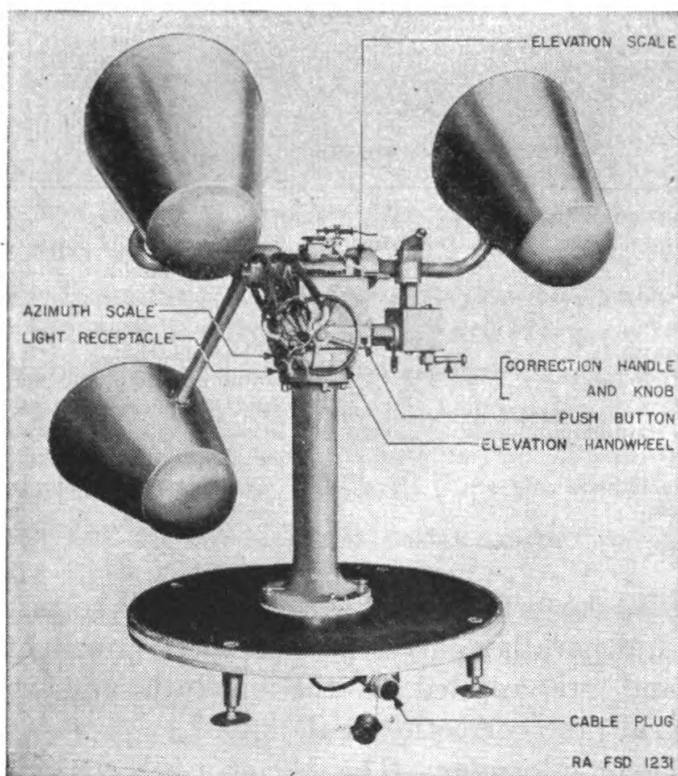
Q. In the M1, M1A1, and M2 acoustic correctors, how are these three corrections applied? (This M2 acoustic corrector is entirely different from the one mounted on the M2 sound locator.) A.—

(1) *M1 and M1A1 acoustic correctors.*—As the operators track the apparent sound source, the azimuth and elevation transmitters are positioned accordingly.

(a) The platoon commander orders the altitude (in feet) to be used. This is applied by the altitude setting knob which positions



① Azimuth side.



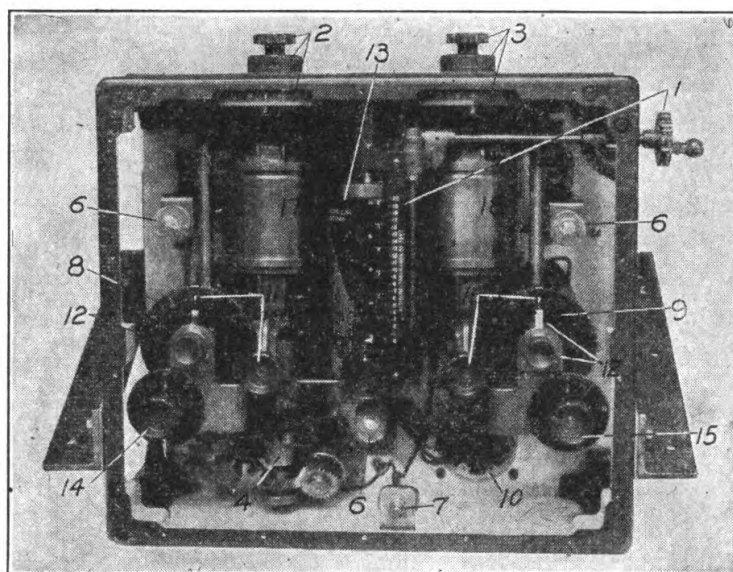
② Elevation side.

FIGURE 135.—Sound locator M2.

the altitude pointer over sound lag time curves appearing on the sound lag cylinder.

(b) The sound lag cylinder rotates as the locator elevates. Sound lag time is read under the altitude pointer. Operators using a stop watch press down on the operating knobs for a period equal to the sound lag time. Sound lag corrections are indicated on inner dial pointers.

(c) Outer dial pointers are matched to inner dial pointers by using the lateral and vertical rate matching knobs, and this operation



- |  |  |
|--|--|
| 1. Altitude scale and setting knob.                      | 10. Plug receptacle.   |
| 2. Corrected azimuth scale and releasing knob.           | 11. Outer predictor scale pointers and operating knobs.                              |
| 3. Corrected elevation scale and releasing knob.         | 12. Inner predictor scale pointers and operating knobs and clutch operating buttons. |
| 4. Differential gears.                                   | 13. Sound lag drum and chart.  |
| 6. Lamp.   | 14. Spotting correction knob, azimuth.   |
| 7. Lamp switch.  | 15. Spotting correction knob, elevation.   |
| 8. Predicting mechanism and scale, azimuth prediction.   | 17. Data transmitter, azimuth.   |
| 9. Predicting mechanism and scale, elevation prediction. | 18. Data transmitter, elevation.   |

FIGURE 136.—Acoustic corrector M1.

applies sound lag corrections through differentials to the transmitters.

(d) Wind and parallax corrections are determined by the platoon commander and are applied to the azimuth and elevation data through the arbitrary correction scale knobs.

(2) *M2 acoustic corrector*.—The M2 acoustic corrector eliminates the use of a stop watch to measure the sound lag time interval. Instead, it uses a motor which causes a tripping device to rotate once every 10 seconds, measuring azimuth and vertical angular rates for

6 seconds, and allowing 4 seconds for matching pointers before the next cycle begins.

(a) A sound lag time computing cam, rotated in elevation and moved right or left in altitude (in feet) solves for the sound lag time. This cam positions the lateral and vertical multiplying cams up or down according to time. Pointers on the lateral and vertical tachometer rate dials indicate the rate of movement in azimuth and elevation, respectively. Matching the rate indexes with these pointers by means of the rate matching knobs rotates the multiplying cams in order to solve for "time  $\times$  rate equals sound lag." When pointers are matched the transmitters are positioned to include the sound lag corrections.

(b) Wind and parallax corrections are determined by the platoon commander and are applied to the azimuth and elevation data through the arbitrary correction scale knobs.

Q. How are sound locators equipped with M1, M1A1, or M2 acoustic correctors oriented? A.—

(1) Level sound locator.

(2) Point sound locator at orienting point (star, searchlight, or distant point) and by means of the releasing knobs (lateral rate at zero) adjust azimuth scale to zero.

(3) Move horns to the zero elevation position, then by means of the releasing knob (vertical rate at zero) adjust vertical scale to zero.

Q. How is the M2 sound locator oriented? A.—

(1) Level sound locator. (Set the target speed to zero.)

(2) Set the parallax scale to zero.

(3) Loosen the azimuth clamp knob (in center of azimuth hand-wheel) and point sound locator at the orienting point (star, searchlight, or distant point) by using the corrector sight and lining up the pantograph pointer with the orienting point.

(4) Tighten azimuth clamp knob to keep sound locator from moving.

(5) Loosen the azimuth sound locator scale and set so that the index pointer indicates zero azimuth.

(6) Push down on the declutching gear and rotate the parallax cam until the arrow on top of the cam points directly at the searchlight, then remesh gearing.

(7) Depress horns to zero elevation as shown on elevation scale.

Q. How is wind corrected for in the M2 sound locator corrector?—

A. The air speed of the plane is used instead of the ground speed. This corrects for the wind component parallel to the course of the plane. Wind component perpendicular to the course is neglected as it is too small to affect the data.

**Q.** In the M2 series sound locator corrector, does the parallax correction apply for all situations?—**A.** No. The base-line distance between the sound locator and searchlight must be known. In addition, the platoon commander must decide at what slant range the target is illuminated. Having the base-line length and slant range of pick-up, the parallax graph found directly beneath the sight is used to deter-

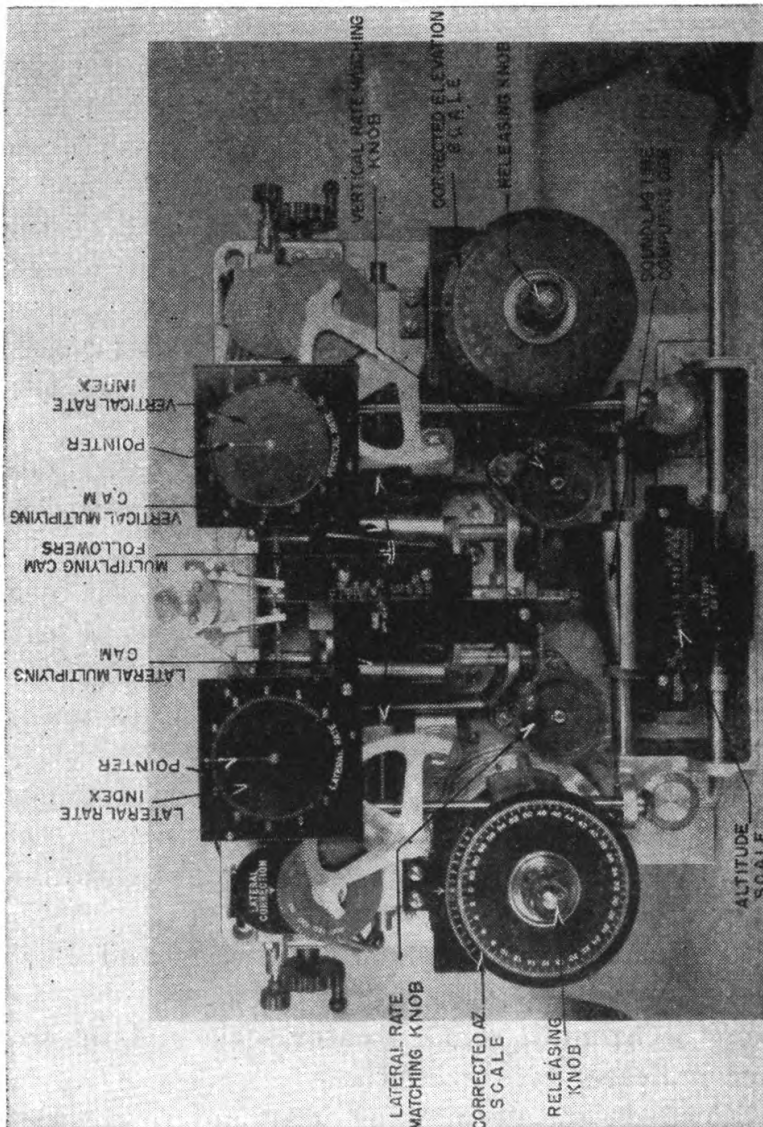


FIGURE 137.—Acoustic corrector M2.

mine a reference number correction. This is applied to scale on the parallax cam. In figure 135, assume a base-line length of 700 feet and an average slant range pick-up of 18,000 feet. The reference number is found by going down the 700 line until the horizontal 18,000 line is intersected, which in this case is 3.1. Apply this correction of 3.1.

*Q.* When is the parallax correction applied?—*A.* After orienting the sound locator and before tracking the target. This correction is applied by setting the parallax scale to the proper reference number.

*Q.* How is air speed of the target obtained and applied to the corrector?—*A.* The outpost listeners, if properly trained, can recognize the type of plane. From this knowledge the platoon commander estimates the air speed, knowing the military characteristics of the plane. This air speed is applied after orienting the sound locator

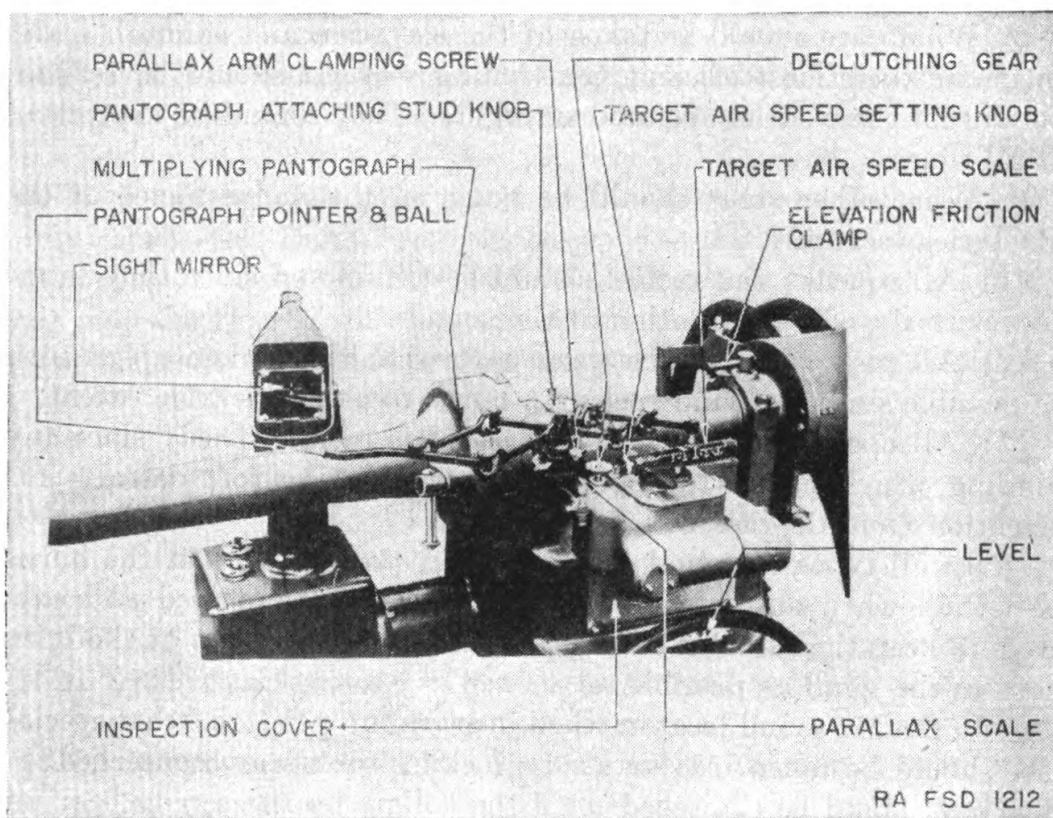


FIGURE 138.—Acoustic corrector, sound locator M2.

and before tracking. It is set in by means of knob on air speed scale.

*Q.* How does the M2 series sound locator apply sound lag corrections?—*A.* As the operators track the plane, the course indicator is positioned so that it points in a direction parallel to the plane course. With the target air speed and parallax scales set, the pantograph pointer is positioned for sound lag, wind, and parallax corrections. These corrections are applied to the transmitter in the corrector unit by moving the sight correction handle and knob so that the pantograph pointer is in the center of the mirror.

**149. Maintenance, care, and adjustment of parts.**—*Q.* Where can instructions be found for the maintenance, care, and adjustment of sound locators?—*A.* In the operator's manual furnished with each sound locator. A complete check of the unit should be made weekly.

*Q.* What are some of the parts of the M1 series sound locator which require greasing at frequent intervals?—*A.* The four hub caps, the main bearing surfaces of the vertical column, and the elevating and traversing wheels. Some grease should be placed on the horn attaching slides to prevent their rusting.

*Q.* What care should be taken of the elevation and azimuth scales to insure their most efficient functioning?—*A.* It should be remembered that these scales are used at night. They should be kept clean at all times.

*Q.* What other steps should be taken in the maintenance of the M1 series locators? *A.*—

(1) All squeaks and rattles should be eliminated since they interfere with the efficient location of the sound.

(2) All play and wear between parts should be taken up as soon as possible since the wind rocks the horns to a considerable extent.

(3) All operating wheels should be made to turn freely since any binding which makes the operator exert special effort detracts his attention from the task of balancing sound.

*Q.* In all types of sound locators, what position should the horns be left in when not being used, and why?—*A.* Depressed and covered, to keep the rain out of them and to expose as little of the open horn to the wind as possible.

*Q.* In the M1 sound locator, when in traveling position, what special care should be taken insofar as the locking screws are concerned?—*A.* They should be tightened until the collars on the screws bear on the base. This removes the strain from the main bearings of the base. It is important that the handwheels not be moved while the mount is locked, as the operating mechanism may thus be broken or seriously damaged.

*Q.* How is the M1 series trailer lubricated?—*A.* It is equipped with alemite fittings which should be checked weekly.

*Q.* How often should the metal mirror of the sight of the M2 series sound locator be cleaned?—*A.* Because of the danger of scratching the highly polished surface it should not be cleaned any oftener than is necessary.

*Q.* What material should be used for cleaning the metal mirror of the M2 sound locator? *A.*—

(1) For cleaning off dust, use soft cotton.

(2) For cleaning off grease, use soft cotton moistened with alcohol.

(3) For exceptionally dirty mirrors during servicing or field operation, a special mixture is applied to soft cotton soaked in alcohol. After this mixture has partly dried remove with absorbent cotton. (Mixture: 3 ounces of precipitated chalk (precipitated calcium carbonate) mixed with 8 ounces of good grade denatured alcohol.)

*Q.* Who is authorized to make complete overhaul, or parts replacement, in the M2 series sound locator?—*A.* Only qualified ordnance personnel.

*Q.* Should the M2 series sound locator be moved while horns are mounted on the corrector assembly?—*A.* No. Horns should be removed if it is necessary to move the sound locator a short distance. For longer distances, the sound locator should be broken down into its six loads.

*Q.* How can you tell what parts of the M2 sound locator should be lubricated?—*A.* Reference must be made to the lubrication section of the operator's manual. The instruction should be followed exactly, using only the type of oil or grease recommended. *Never allow any part of the sound locator to become rusty. Keep leveling jacks clean.*

## SECTION IV

### TACTICAL EMPLOYMENT OF SEARCHLIGHT SECTION

|  | Paragraph |
|--|-----------|
| Organization .....   | 150       |
| Employment of section; selection and preparation of positions..... | 151       |

**150. Organization.**—*Q.* What is the tactical unit of the searchlight battery?—*A.* The platoon.

*Q.* Of how many searchlight sections does a platoon consist and what primary units are in each section?—*A.* Of five sections, complete with sound locator, control station, searchlight, and power plant.

*Q.* How many platoons are there in a searchlight battery?—*A.* Three.

**151. Employment of section; selection and preparation of positions.**—*Q.* What is the function of the searchlight battery?—*A.* To provide illumination of any aerial targets which may approach the defended area; to furnish intelligence as to airplane activity in the vicinity; to cooperate with friendly aircraft both by sending signals by means of the main searchlight and by illuminating targets for attack by friendly aircraft.

**Q.** Where should the platoon command post be located?—**A.** Normally at one of the outer lights, preferably the center outer light of the platoon.

**Q.** How far apart should the searchlights be under normal conditions?—**A.** Not over 5,000 yards apart.

**Q.** What communication lines are run by the platoon?—**A.** To each searchlight in the platoon and to distant observation posts in the platoon sector, when ordered.

**Q.** What is the usual distance between the various elements of the section, based on the length of cable connecting adjacent units?—**A.** Between searchlight and sound locator, 900 feet; between searchlight and power plant, 200 feet; and between searchlight and control station, 500 feet.

**Q.** What is the usual layout of the major items of equipment of a searchlight section?—**A.** Usually the sound locator and power plant are set up on opposite sides of the searchlight. They should be the greatest possible distance apart so that the effect of power plant noises on the operation of the sound locator will be reduced to a minimum. The control station should be located on a flank of the searchlight and on a line approximately perpendicular to the line, power plant-searchlight-sound locator.

**Q.** Name some requirements of a good searchlight position. **A.**—

(1) Unobstructed field of illumination. This is usually found on an open plain or high ground.

(2) Concealment of position and approaches. In addition, defilade should be sought in forward areas.

(3) In case of movement, the new position selected should be one that the unit can readily move into or out of.

(4) Noninterference with or by other troops. Searchlights draw fire; also the unit cannot work satisfactorily when within 1 mile of gun positions and should get away from all sources of noise such as railroad and other traffic whenever possible.

(5) Cover for power unit.

(6) Suitable positions for control station and sound locators.

**Q.** How should the personnel of the searchlight section be employed during the daytime?—**A.** In the necessary inspection and maintenance of equipment and in rest, since they are active throughout the night. In addition, manning of certain positions may be required by observers for intelligence purposes, and local protection must always be considered.

**Q.** In rear areas how are the lights usually placed?—**A.** The lights are usually placed in an inner ring of carry lights and an outer

ring of pick-up lights. The minimum radius of the inner ring is 2,500 yards for areas 1,000 yards or less in diameter. The radius of the outer ring will average about 8,500 yards, as pick-up lights will not be placed over 5,000 yards apart.

*Q.* What is considered the maximum horizontal distance at which a searchlight can pick up an airplane under favorable conditions?—*A.* Five thousand yards.

*Q.* When should carry lights take over targets from pick-up lights?—*A.* Before the targets reach the line of pick-up lights.

*Q.* Normally, how many lights should be assigned to carry a single target?—*A.* At least two.

*Q.* What are the best means of protection for lights against artillery fire?—*A.* Defilade and frequent change of position.

*Q.* Mention some precautions against low-flying combat aviation. *A.*—

(1) When not in action, keep concealed.

(2) If discovered when in action, occult the light or use it to blind the pilot.

(3) Have the automatic rifles sited to engage properly suitable targets.

(4) Erect sandbag revetments around the units.

*Q.* Should emplacements be used for searchlights?—*A.* Generally speaking, no. The searchlight is a small target and should depend upon darkness for its protection. The positions of the searchlights should be shifted nightly in the same general vicinity. However, in some areas, due to interference with other troops, it will be impossible to move lights nightly, in which case the lights should be dug in.

*Q.* As a rule, what should be done with searchlight equipment during the daytime?—*A.* It should be taken out of the position and placed in a well concealed locality. The various pieces of equipment should be again emplaced at dusk.

(In addition to the foregoing, a knowledge of the material contained in paragraphs 155, 156, and 158 is required.)

## CHAPTER 10

## GENERAL SUBJECTS

|  | Paragraphs |
|--|------------|
| SECTION I. Definitions and elementary principles for antiaircraft artillery----- | 152-154    |
| II. Organization of position or bivouac-----                                     | 155-158    |
| III. Map reading-----  | 159-162    |
| IV. Elementary principles of electricity, magnetism, and induction-----          | 163-164    |
| V. Ammunition—advanced-----  | 165-166    |

## SECTION I

## DEFINITIONS AND ELEMENTARY PRINCIPLES FOR ANTIAIRCRAFT ARTILLERY

|                                      | Paragraph |
|--------------------------------------|-----------|
| General terms-----                   | 152       |
| Searchlights and sound locators----- | 153       |
| Supply and ammunition-----           | 154       |

**152. General terms.**—The following definitions have been selected as typical of the class of definitions with which the antiaircraft artilleryman should be familiar. Additional terms will be found in FM 4-155.

*Air speed.*—The speed of an airplane with reference to the air through which it is flying. The air speed differs from the ground speed by the effect of the wind on the movement of the airplane.

*Altitude.*—The vertical distance of a target or point in space above the horizontal or level plane through the directing point of the battery.

*Angle of approach.*—The acute (lesser) horizontal angle between the plane of position and the vertical plane containing the course of the target.

*Angular height.*—The vertical angle between the line of position (site) and the horizontal.

*Angular travel method.*—A method of determining firing data based on the lateral and vertical rates of angular travel of a target.

*Axis of bore.*—The center line of the bore of the gun.

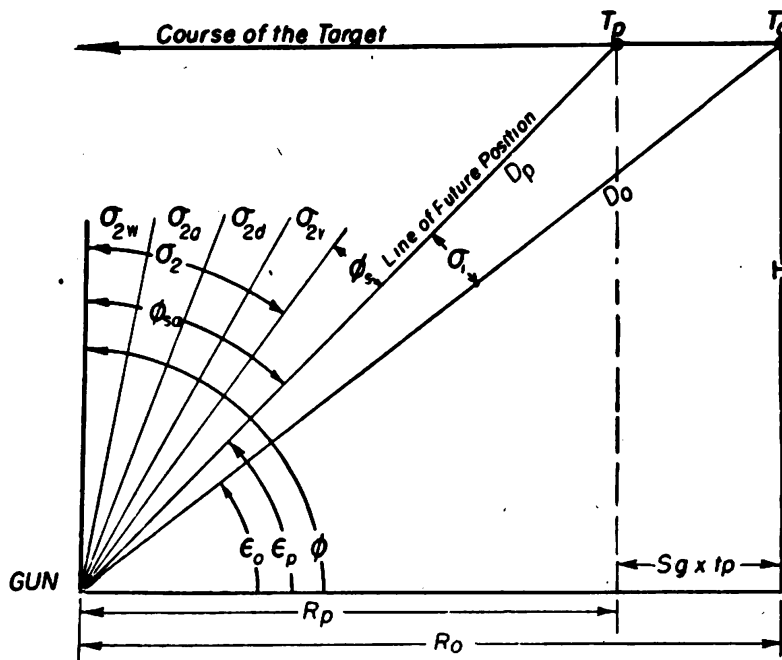
*Azimuth.*—The horizontal angle measured in a clockwise direction, from a selected reference line (usually the grid north line) passing through the position of the observer, to the horizontal projection of the line of sight from the observer to the objective.

**Back azimuth.**—The azimuth plus or minus  $180^\circ$  or 3,200 mils. The opposite direction.

**Ballistic density.**—A fictitious constant density of the atmosphere which will have the same total effect on the projectile during its flight as the actual density conditions. Ballistic wind is a similar fictitious wind value.

# VERTICAL PROJECTION

(Visualized) airplane approaching directly over the battery

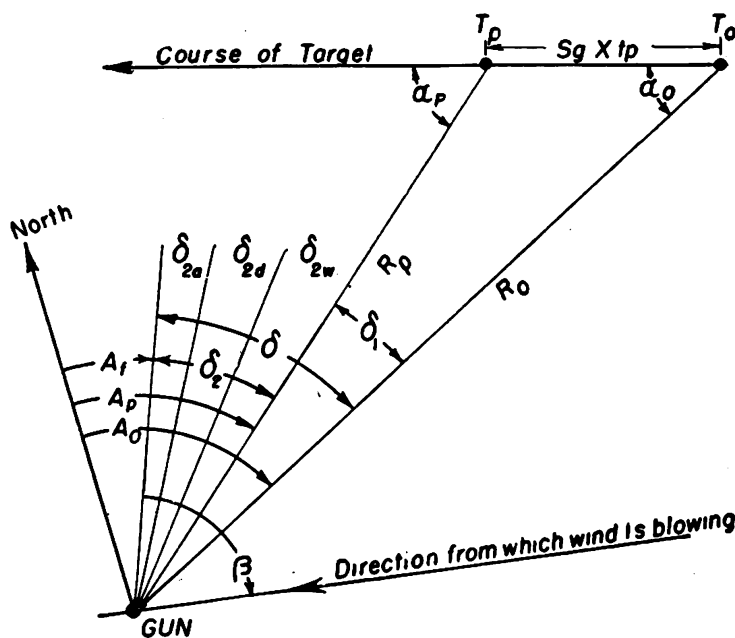


- $D_p$  Slant range to target at future position ( $T_p$ ).
- $D_o$  Slant range to target at present position ( $T_o$ ).
- $\epsilon_p$  Angular height of target at future position ( $T_p$ ).
- $\epsilon_o$  Angular height of target at present position ( $T_o$ ).
- $H$  Altitude of target.
- $\phi$  Quadrant elevation.
- $\phi_o$  Superelevation under firing table conditions.
- $\phi_a$  Superelevation under actual conditions.
- $R_p$  Horizontal range to target at future position ( $T_p$ ).
- $R_o$  Horizontal range to target at present position ( $T_o$ ).
- $S_g$  Ground speed of target.
- $S_g \times t_p$  Linear travel of target in horizontal plane during time of flight.
- $\sigma_1$  Principal vertical deflection angle.
- $\sigma_2$  Vertical pointing correction.
- $\sigma_{2a}$  Vertical adjustment correction (arbitrary).
- $\sigma_{2d}$  Vertical pointing correction due to density.
- $\sigma_{2w}$  Vertical pointing correction due to muzzle velocity.
- $T_p$  Predicted position of target (future position).
- $T_o$  Present position of target (instant of firing).
- $t_p$  Time of flight to future position of target ( $T_p$ ).

FIGURE 139.—Elements of data, angular travel method (vertical projection).

**Base line.**—A line of known length and direction between the primary (battery) and one of the secondary (flank) observation or spotting stations, the position of which with respect to the battery is known. The base line is called *right-handed* or *left-handed* depending on whether the secondary station is to the right or left of the primary station from the point of view of a person facing the field of fire.

**Base piece.**—See Directing point.



HORIZONTAL PROJECTION

- $A_p$  Azimuth of target at future position ( $T_p$ ).
- $A_o$  Azimuth of target at present position ( $T_o$ ).
- $A_f$  Firing azimuth.
- $\alpha_p$  Angle of approach at future position ( $T_p$ ).
- $\alpha_o$  Angle of approach at present position ( $T_o$ ).
- $\beta$  Wind-fire angle.
- $\delta$  Lateral deflection angle.
- $\delta_1$  Principal lateral deflection angle.
- $\delta_2$  Lateral pointing correction.
- $\delta_{2a}$  Lateral adjustment correction (arbitrary).
- $\delta_{2d}$  Lateral pointing correction due to drift.
- $\delta_{2w}$  Lateral pointing correction due to cross wind.
- $R_p$  Horizontal range to target at future position ( $T_p$ ).
- $R_o$  Horizontal range to target at present position ( $T_o$ ).
- $S_t$  Ground speed of target.
- $S_t \times t_p$  Linear travel of target in horizontal plane during time of flight.
- $T_p$  Predicted position of target (future position).
- $T_o$  Present position of target (instant of firing).
- $t_p$  Time of flight to future position of target ( $T_p$ ).

FIGURE 140.—Elements of data, angular travel method (horizontal projection).

**Bore.**—The interior of a cannon forward of the front face of the breechblock (or bolt). The length of the bore is the distance from the front face of the breechblock proper to the muzzle, measured along the axis of the bore.

*Center of burst.*—The mean position in space of a series of bursts.

*Dead time.*—The time necessary to compute and utilize an element of the firing data.

*Deflection.*—The angular amount by which the gun must lead the target at the instant of firing in order to hit the target.

*Degree.*—A unit of angular measure; a circle is divided into 360 equal parts or degrees.

*Deviation.*—The angular or linear displacement of a point of burst, center of burst, or center of a cone of fire from the target or adjusting point.

*Directing point.*—A point in or near a battery for which the firing data are determined. If a gun of the battery is the directing point, it is called the base piece or directing gun.

*Dispersion.*—The scattering of shots fired with the same data.

*Displacement.*—The distance from one point to another point. *Gun displacement* is the horizontal distance in yards from the pintle center of the gun to the directing point or directing gun of the battery.

*Drift.*—The departure of a projectile from the vertical plane in which it is fired, caused by the rotation of the projectile and the resistance of the air. In the United States service, drift is always to the right.

*Firing data.*—All data necessary to give a gun the proper elevation, direction, and fuze setting for firing at a given target.

*Fuze.*—A device attached to a projectile which controls the time of burst of the projectile.

*Fuze range.*—The fuze setting necessary to produce a burst at the desired point along the trajectory.

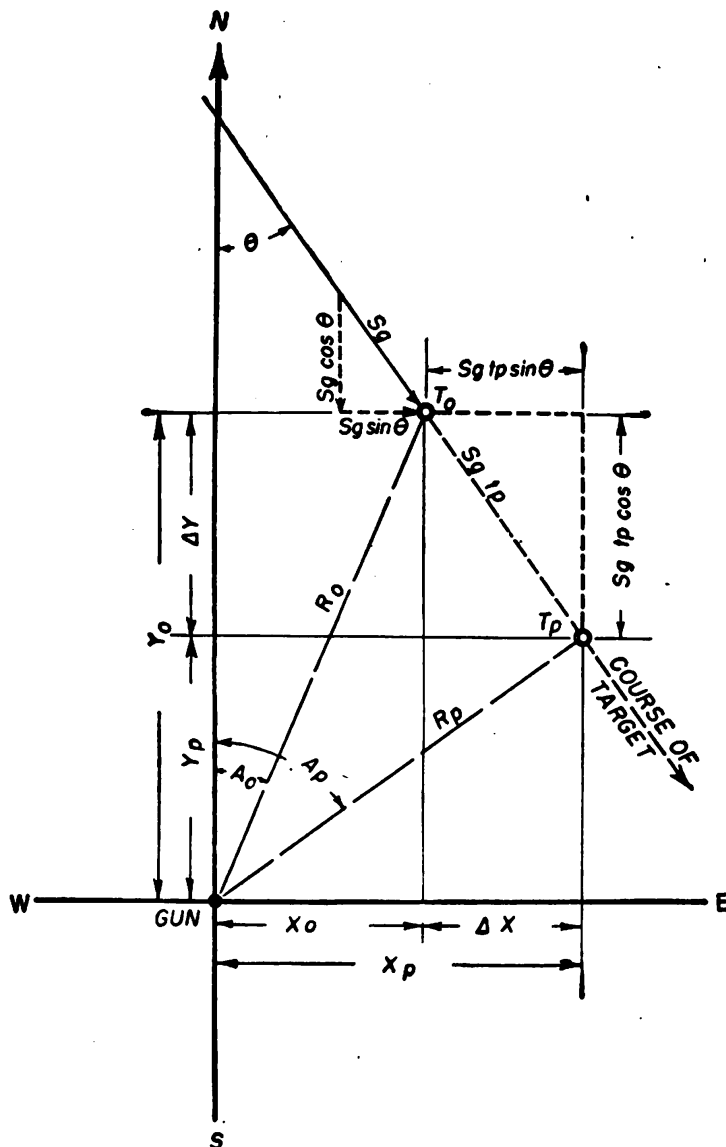
*Ground speed.*—The speed or linear velocity of the target with reference to the ground. The ground speed of the target is its air speed plus or minus the effect of the wind.

*Gunner's quadrant.*—An instrument used on the quadrant seat of a cannon to measure the vertical angle between the axis of the bore and the horizontal.

*Lateral deflection.*—The horizontal angle value which allows for the lateral travel of the target during the time of flight and for lateral pointing corrections. It is the angle between the vertical plane of present position and the axis of the bore when the gun is laid.

*Laying.*—See Pointing.

*Leveling.*—The process of adjusting a gun and mount or any fire-control or observation instrument, so that all horizontal or vertical angles will be measured or applied in truly horizontal or vertical planes.



- $A_0$  Azimuth of target at present position ( $T_0$ ).  
 $A_p$  Azimuth of target at future position ( $T_p$ ).  
 $\Delta X$  or  $S_t \times t_p \sin \theta$  East-west component of travel of target during time of flight of projectile.  
 $\Delta Y$  or  $S_t \times t_p \cos \theta$  North-south component of travel of target during time of flight of projectile.  
 $R_0$  Horizontal range to target at present position ( $T_0$ ).  
 $R_p$  Horizontal range to target at future position ( $T_p$ ).  
 $S_t$  Ground speed of target.  
 $S_t \cos \theta$  or N-S rate North-south component of ground speed of target.  
 $S_t \sin \theta$  or E-W rate East-west component of ground speed of target.  
 $S_t \times t_p$  Linear travel of target in horizontal plane during time of flight.  
 $\theta$  Angle between vertical planes containing course of target and north-south axis of data computer. (Never greater than  $90^\circ$ ).  
 $T_0$  Present position of target at instant of firing.  
 $T_p$  Future or predicted position of target.  
 $t_p$  Time of flight to future position of target.  
 $X_0$  East-west component of horizontal range to present position.  
 $X_p$  East-west component of horizontal range to future position.  
 $Y_0$  North-south component of horizontal range to present position.  
 $Y_p$  North-south component of horizontal range to future position.

FIGURE 141.—Elements of data, linear speed method (horizontal projection).

*Linear speed method.*—A method of determining firing data based upon linear speed of the target.

*Line of position.*—The line of position of a point is the straight line connecting the origin with that point. Also called the *line of site*. The point of origin is usually the gun or a position-finding instrument.

*Mil.*—A unit of angular measure, commonly used in gunnery. There are 6,400 mils in a circle, or 1,600 in a right angle. A mil is approximately the angle subtended by 1 yard at a distance of 1,000 yards.

*Orientation.*—The establishment of true horizontal directions. Guns and instruments are said to be oriented when they are so leveled and adjusted that they will read correct azimuth or point in the right direction when an azimuth is set on them. A map is oriented when the meridian shown on the map is pointing toward north on the ground.

*Parallax.*—The difference in azimuth or direction of a point as viewed from two other points.

*Plane of fire.*—The vertical plane containing the axis of the bore when the gun is ready to fire.

*Plane of position.*—A vertical plane containing a line of position.

*Pointing.*—The operation of giving a piece a designated elevation and a direction for firing. When a sight is used to perform either of these operations it is called aiming; if a sight is not used the method is called laying.

*Pointing corrections.*—That part of either the lateral or vertical deflection which corrects for factors other than the travel of the target, such as wind, drift, and density and muzzle velocity as they apply. It includes adjustment corrections.

*Position finding.*—The process of determining the present and future positions of a target (range and direction) for the purpose of directing fire upon it.

*Positions of the target.*—Two positions of the target are considered: Position of target at instant of firing or present position (*T-sub-o*), and position of target as predicted (*T-sub-p*). This is the predicted position of the target at the end of the predicted time of flight. There is a corresponding value of angular height, slant range, and horizontal range for each position.

*Predicting.*—The process of determining the expected position of the target at some future time.

*Quadrant elevation.*—The vertical angle between the horizontal and the axis of the bore when the gun is ready to fire.

*Sense.*—The direction of a point of impact (burst), center of impact (burst), or center of a cone of fire with respect to the target, as: over or short, right or left, above or below.

*Slant range.*—The distance from the origin (usually a gun or position-finding instrument) to the target along the line of position.

*Spotting.*—The process of determining from observation the position of a burst or of the center of a cone of fire with respect to a target or adjusting point.

*Superelevation.*—That part of the quadrant elevation which allows for the curvature of the trajectory.

*Symbols.*—Letters used to represent certain elements of firing data, angles, or position of the target. For example:  $\epsilon$  (epsilon) represents angular height;  $\phi$  (phi), quadrant elevation;  $H$ , altitude;  $F$ , fuze range; and  $R$ , horizontal range.

*Time of flight.*—The elapsed time from the instant the projectile leaves the bore to the instant of impact (burst).

*Trajectory.*—The curve described by the center of gravity of a projectile in its flight.

*Trial fire.*—Deliberate fire at a point in space to determine corrections for firing data. Normally five rounds are fired, all from the same gun.

*Trial shot point.*—A point in the field of fire, visible from observation stations, at which trial shots are fired.

*Vertical deflection.*—That vertical angle which must be added or subtracted from the present angular height to allow for the vertical travel of the target during the time of flight and for vertical pointing corrections.

*Wind fire angle.*—The horizontal angle, measured clockwise from the plane of fire to the direction from which the ballistic wind is blowing.

*Q.* Draw a figure (vertical projection) and indicate the following:

- (1) Present position.
- (2) Future position.
- (3) Present angular height.
- (4) Vertical deflection.
- (5) Superelevation.
- (6) Quadrant elevation.
- (7) Altitude.

*Q.* Draw a figure (horizontal projection) and indicate the following:

- (1) Present horizontal range.
- (2) Present azimuth.
- (3) Lateral deflection.

(4) Angle of approach.

(5) Wind fire angle.

**153. Searchlights and sound locators.**—The following definitions pertain to searchlights and sound locators:

*Ampere.*—A unit for measuring the quantity of an electric current.

*Apparent sound source.*—The position from which the sound of a target seems to come.

*Arc.*—The luminous flame occurring between the two electrodes (carbons) of a searchlight when connected to a source of electricity.

*Circuit.*—The entire path of an electric current from its source back to the same source. When it is completed so that current will flow it is said to be closed; when it is interrupted so current stops it is said to be broken or open.

*Control, distant.*—A system, electrically operated, by which the pointing of searchlights may be controlled from a distance. The system includes a controller at the control station, the necessary electrical circuits, and the necessary motors at the searchlights.

*Control station.*—A device which permits the searchlight to be pointed in elevation and azimuth from a distant point. The station consists of a distant electric controller and a zero reader mounted on a tripod.

*Current, electric.*—The flow of electricity along a conductor, which is like the flow of water through a pipe. The pressure which causes the current to flow is called *electromotive force (EMF)*, *potential*; or *voltage*. The amount of current that flows is measured in amperes.

*Data.*—All information necessary for pointing a searchlight at a given objective.

*Electrode.*—Either of the two carbons, positive and negative, across which the arc is formed in a searchlight.

*Focal point.*—The position of the arc at the proper distance from the mirror so that the light rays are properly reflected parallel to each other as a compact beam.

*Focus.*—To move the light source in a searchlight with reference to the focal point of the reflector.

*Illumination.*—The lighting of a target by a searchlight beam directed and held on the target. A momentary catching of the target in the beam is called a flick.

*Occluder.*—A shutter for hiding the beam of a searchlight so that it cannot be seen and located by an enemy when the beam is not needed.

*Orientation.*—As applied to a searchlight, adjusting the searchlight and sound locator so both will point in the same (parallel) direction when a certain azimuth is set on both.

*Parabolic.*—The shape of the searchlight mirror which causes light from a source at the focal point of the mirror to be reflected in parallel rays.

*Prediction data.*—The azimuth and elevation which the searchlight receives from the sound locator after they have been corrected by the acoustic corrector.

*Sound.*—The vibrations of a sounding body, which set up sound waves, by which the sound is carried to the ear. Sound requires a noticeable time to travel through the air (1,100 feet per second).

*Sound lag.*—The angular difference between the actual (present) position of the target and the apparent position as indicated by sound.

*Sound lag corrections.*—The corrections applied to the azimuth and elevation to take care of sound lag.

*Terminal voltage.*—The voltage of the electric current at the electrodes in the searchlight.

*True sound source.*—The actual azimuth and elevation of the sound source at the instant the sound is produced.

*Velocity of sound.*—Sound travels very slowly at a rate of about 1,100 feet per second.

*Volt.*—A unit for measuring the potential of an electric current. (See Current, electric.)

*Wind drift.*—The effect of wind on the sound waves which changes their direction and increases or decreases sound lag.

*Zero reader.*—A device for indicating when the searchlight is properly pointed on corrected sound locator data.

**154. Supply and ammunition.**—The following definitions pertain to supply and ammunition:

*Ammunition train.*—A train organized particularly for supply of ammunition for the battalion.

*Classes of supplies.*—Supplies are divided into classes, as follows:

*Class I.*—Rations and items required daily, irrespective of operations.

*Class II.*—Individual and organizational equipment as established by Tables of Organization and Tables of Allowances, such as clothing and gas masks.

*Class III.*—Engine fuels and lubricants including gasoline for all vehicles and aircraft, Diesel oil, fuel oil, and coal.

*Class IV.*—Exceptional items not covered in Tables of Allowances, such as construction materials and machinery.

*Class V.*—Ammunition, including chemicals.

*Distributing point.*—A place, other than a depot or a railhead, where supplies are issued to regiments and smaller units.

*Dump.*—A place for the temporary storage of supplies. Dumps may be specially named, depending on the kind of supplies they contain, as ammunition dump, ration dump, and engineer dump. When supplies are issued from a dump, it becomes a distributing point.

*Memorandum receipt.*—A receipt given to the supply officer by the person drawing supplies from him or a receipt given by the supply officer to the person returning supplies to him.

*Railhead.*—A supply point where loads are transferred from rail transportation to organization trains.

*Ration.*—The allowance of food for one man or one animal for 1 day. There are several classes of rations, according to the conditions of service, as garrison, field, and emergency.

*Requisition.*—A request for supplies to a higher commander, which when approved by him, is an order for issue of supplies by the proper supply department to the supply officer of the unit which submitted the requisition.

*Shipping ticket.*—A form which accomplishes a shipment of supplies to a supply officer and which he must sign and return to the shipping officer to accomplish transfer of accountability.

*Train.*—That portion of a unit's transportation, including personnel, operating under the immediate orders of the unit commander, primarily for supply, evacuation, and maintenance.

*Unit of fire.*—The quantity in rounds or tons of ammunition, bombs, grenades, and pyrotechnics which a designated organization or weapon may be expected to expend, on the average, in 1 day of combat.

## SECTION II

### ORGANIZATION OF POSITION OR BIVOUAC

|   | Paragraph |
|---|-----------|
| Camouflage and camouflage discipline.....   | 155       |
| Protection against low-flying aircraft..... | 156       |
| Construction of shelters.....               | 157       |
| Protection against sabotage and raids.....  | 158       |

**155. Camouflage and camouflage discipline.**—*Q.* What is military camouflage?—*A.* Military camouflage is the art of deceiving the enemy as to the existence, nature, or extent of military works or bodies of troops.

*Q.* How may camouflage be effected? *A.*—

(1) By simple concealment.

(2) By making an object or area blend with surrounding objects or areas.

(3) By making an object appear like something else.

(4) By avoiding regularity of form or spacing, and breaking up straight lines of artificial works.

(5) By avoiding skylining.

(6) By suppressing telltale shadows.

(7) By avoiding noticeable changes in previous appearance of the terrain.

(8) By erecting dummy installations to divert the attention from real objects.

(9) By suppressing all signs of military activity.

*Q.* How may a gun position be camouflaged? *A.*—

(1) By spreading a fish net or wire netting, interlaced with leaves, branches, grass, and weeds, or tufts of burlap over the position.

(2) By spreading painted burlap over the position.

(3) By use of natural materials, such as brush, shrubs, and small trees.

*Q.* What is the most important consideration in the camouflage of an area?—*A.* Selection of ground which lends itself to the concealment of troops and their equipment.

*Q.* What points should be remembered when erecting camouflage?—*A.* That not only must the object or area be camouflaged from observers on the ground, but especially from observers in the air, and most particularly it must be so camouflaged as not to appear on photographs taken from airplanes. It must be especially noted that points which the human eye may not pick up or notice often stand out most prominently on a photograph, or may be detected on a photograph by use of a magnifying glass.

*Q.* What are some things that betray an object, position, or area and how are they to be avoided? *A.*—

(1) *Tracks.*—Beaten tracks, or even footprints in the snow or in a grassy field, are very noticeable on a photograph. To avoid tracks, insist that men keep to paths and do not cut the corners.

(2) *Paths.*—Keep paths close to fences, hedges, houses, and along the edges of a field if possible. Never allow a path to lead to a position or object and end there. Always have it lead past the position or object and stop in a wood or join another path or a road. Have this path used as much as the real one.

(3) *Allowing men to wander about in daytime.*—Make them stay under cover, to prevent detection from the air.

(4) *Camouflage which does not blend in with its surroundings.*—For example, if in a wooded area, do not camouflage a position of a house or ruins.

(5) *Regularity.*—Remember that nothing regular occurs in nature. Therefore, if using painted canvas or burlap, have jagged splotches rather than straight lines or regular shapes and figures.

(6) *Shadows.*—Avoid regular shapes. In covering an object with fish net, interlace the material thinly toward the edges so as to break up and conceal the shadow of the net.

(7) *Changes in previous appearance of terrain.*—The enemy may be expected to take successive photographs of the terrain. Any object which might appear innocent in itself is sure to invite scrutiny if it appears on one photograph when it was not visible on a previous photograph of the same terrain.

(8) *Flash marks.*—If using a net, roll it back before firing. If a gun is emplaced among ruins, prevent flash marks, or remove them immediately, as circumstances permit. If firing in a woods, arrange branches so that they may be pulled out of the way of the gun while firing.

Q. Name two important passive means of defense that can be used for protection against hostile observation and attack.—A. Dispersion and concealment.

Q. What is the value of dispersion?—A. It limits the number of units or elements that may be destroyed or damaged by one bomb, shell, or burst of fire. It also tends toward concealment.

Q. Why is concealment difficult for anti-aircraft guns?—A. Because anti-aircraft guns must be ready to fire without any delay and in any direction.

Q. What is the best kind of ground, with regard to concealment, for emplacing anti-aircraft guns?—A. An area covered with low brush or scrub about shoulder high. Branches can then be scattered over the gun to give effective concealment and still be quickly thrown off when a target approaches. Where a net is used it must have a flap which can be pulled back quickly.

Q. What is the value of concealment in the defense of a bivouac area?—A. By limiting hostile observation, it is a most effective means of minimizing the effects of hostile attacks. This is accomplished by a careful choice of the bivouac area, maximum use of natural and artificial cover, camouflage, and camouflage discipline.

**156. Protection against low-flying aircraft.**—Q. What types of attack may be delivered by low-flying aircraft against anti-aircraft personnel and matériel?—A. Attacks by light and dive bombardment

aviation employing demolition and fragmentation bombs, automatic weapons, and gas.

*Q.* What active means of defense available to the ground forces are most effective against this form of attack?—*A.* The antiaircraft automatic weapon.

*Q.* What passive means are most effective against this form of attack?—*A.* Adequate cover, concealment, dispersion, and individual and collective gas protection.

*Q.* How are personnel warned of an impending attack?—*A.* By three blasts of a whistle, three shots from a gun, or by the use of some other noise-making device such as a siren or gong.

*Q.* How is an attack by low-flying aircraft met?—*A.* All available automatic weapons should be set up to protect a bivouac area or position, and should be manned as soon as the alarm is given. Whether protected or not, troops should scatter and open fire on the plane with any weapons they may have. If actually engaging another plane it will be necessary for them to remain at their positions. If a column is on the march it may be protected by machine guns in trucks.

**157. Construction of shelters.**—*Q.* What is a shelter?—*A.* A shelter is any cover, natural or artificial, that protects troops, ammunition, and supplies from fire, gas, or aerial bombs.

*Q.* Should large quantities of ammunition be stored in one shelter?—*A.* No. It is preferable to have several shelters in order to limit the damage that may result from a single hit.

*Q.* Against what kind of shells should artillery troops be protected?—*A.* High-explosive shell, gas shell, and bombs dropped from airplanes.

*Q.* How near should shelters be to the gun positions?—*A.* Just as near as possible, consistent with safety and concealment (usually not over 100 yards). The purpose of shelters is to afford the troops protection *close* to their combat positions. Personnel of antiaircraft batteries especially must be near the guns.

*Q.* How are shelters classified according to their depth? *A.*—

(1) Surface shelters, constructed above the ground.

(2) Cut-and-cover shelters, made by digging an open pit which is then provided with overhead cover, usually extending above the surface.

(3) Cave shelters, which are subterranean chambers protected by the undisturbed earth above them.

*Q.* What determines the type and strength of shelter to be constructed?—*A.* The terrain, the time and material available, the amount of protection required, and the probable length of time the position will be occupied.

**Q.** If the position is liable to come under fire of guns of 5-inch caliber and above, what type of shelters should be provided?—**A.** Cut-and-cover or cave shelters.

**Q.** Which type of shelter requires the greatest amount of concealment?—**A.** Surface, cut-and-cover, and cave, in the order named.

**Q.** How are shelters protected against gas?—**A.** By placing a curtain of canvas, blanket, or other suitable material, weighted at the bottom, across each entrance. If it is possible, a gas trap or lock should be made by means of a short passageway into the shelter with a gas curtain at the inner end, and another at the outer end of the passageway.

**Q.** What precautions should be taken in using old shelters?—**A.** Inspect them carefully to be certain there is no gas in them.

**Q.** Are large or small shelters preferable?—**A.** From a tactical point of view several small shelters are preferable to one large one, as they permit troops to get out to their positions more quickly.

**158. Protection against sabotage and raids.**—**Q.** For what purpose may attacks by hostile mechanized forces be conducted?—**A.** Such attacks may be used by the enemy while conducting missions on raids to destroy important installations, to harass the defense forces, to disrupt the communication system, or in support of an attack by other forces.

**Q.** Who is responsible for the antimechanized defense of a command?—**A.** The commander of every unit is responsible for the security of his command against mechanized attacks and raids.

**Q.** What are some of the matters to be considered in siting anti-mechanized weapons for the defense of an area?—**A.** Full use of natural and artificial obstacles is planned, and antimechanized weapons should be sited accordingly, some to cover obstacles, but the bulk to cover available avenues of approach. Coast artillery units have automatic weapons of some type for defense. As these weapons are normally for antiaircraft defense, choice of positions may require careful consideration, and coordination by higher commanders may be necessary.

**Q.** What are some of the requirements of a suitable position for antimechanized guns?—**A.** Good fields of fire at ranges up to 1,000 yards, possibilities of flanking fire, protection against direct mechanized attack, covered routes to firing positions, availability of alternate emplacements which can be occupied quickly by manhandling gun, and nearby cover for ammunition. The position should permit shifting fire to any direction from which attack may be probable.

*Q.* Name three means of attaining security against hostile mechanized attacks? *A.*—

- (1) Information of the enemy.
- (2) Concealment.
- (3) Organization of the ground.

*Q.* What elements of enemy information should be procured for the attainment of security against hostile ground attacks and raids?—*A.* Timely, accurate, complete, and continuous information of enemy dispositions, movements, composition, strength, and capabilities.

*Q.* In the attainment of security against hostile ground attacks and raids, what is meant by organization of the ground?—*A.* Organization of the ground includes construction or improvement of obstacles, clearing of fields of fire, selection and preparation of defensive positions, and construction of splinter-, bomb-, and gas-proof shelters.

*Q.* What special precautions should be taken to avoid surprise by hostile mechanized units?—*A.* Such precautions should include—

- (1) Fullest possible use of intelligence and communication agencies of the command.
- (2) Patrols to cover bridges, swamp crossings, or other lines of approach to batteries, bivouacs, or installations.

*Q.* What is sabotage?—*A.* Malicious destruction of or injury to property by enemy sympathizers.

*Q.* What acts of sabotage might be expected against antiaircraft artillery installations?—*A.* Acts of sabotage to be expected vary from simple depredations, such as the cutting of telephone lines, to attempts at demolition of matériel.

*Q.* During what stages of a conflict is the danger of sabotage greatest?—*A.* During the early stages.

*Q.* What special precautions should be taken against sabotage and to avoid surprise by raiding parties?—*A.* Precaution should include—

- (1) Continuous effective employment of the intelligence agencies and the communication systems of the command.
- (2) Effective patrolling to cover bridges, causeways, swamp crossings, roads and trails, and other avenues of approach to positions, installations, and bivouacs.
- (3) Constant vigilance at remote stations and positions.
- (4) Protection of closely grouped installations by interior guards.

### SECTION III

## MAP READING

|   | Paragraph |
|---|-----------|
| Scales, contours, and conventional signs.....             | 159       |
| Location of position by coordinates.....                  | 160       |
| Following route indicated on map.....                     | 161       |
| Data as to roads, bridges, fords, grades, and swamps..... | 162       |

**159. Scales, contours, and conventional signs.—Q.** What is a map?—**A.** A map is a picture of an area of ground, which shows certain important features accurately to scale.

**Q.** Do the features shown on a map appear as they do on the ground?—**A.** No. They are represented by symbols called conventional signs, which resemble the actual features as nearly as practicable.

**Q.** What is a topographical map?—**A.** One which (according to its scale) shows all the natural and artificial features of the terrain, such as hills, valleys, streams, woods, roads, towns, houses, and bridges.

**Q.** What is a military map?—**A.** military map is one which shows particularly those features and conveys that information, which are important for military purposes.

**Q.** What is meant by map reading?—**A.** Map reading is the art of understanding the information given by the map.

**Q.** What is meant by the scale of a map?—**A.** The scale of a map is the relation between any distance shown on the map and the corresponding distance on the ground. It is always the same for any one map.

**Q.** How is the scale of a map indicated or expressed? **A.—**

(1) As a representative fraction (RF), such as 1/5,000 (or 1:5,000), which means that any distance on the map is 1/5000 of the corresponding distance on the ground. The RF is always expressed with a numerator of *unity*. The RF is always the ratio of a map distance to the actual or ground distance it represents. Thus if 2 inches (on the map) represent 10 miles on the ground, the relation can at once be expressed thus:

$$\frac{\text{Map distance}}{\text{Ground distance}} = \frac{2 \text{ inches}}{10 \text{ miles}}$$

The numerator and denominator must then be reduced to the same unit, and the numerator then reduced to unity to get the RF, as follows:

$$\begin{aligned} \frac{2 \text{ inches}}{10 \text{ miles}} &= \frac{2 \text{ inches}}{10 \text{ miles} \times 5,280 \text{ feet} \times 12 \text{ inches}} \\ &= \frac{2 \text{ inches}}{633,600 \text{ inches}} = \frac{1}{316,800} = \text{RF.} \end{aligned}$$

(2) In words and figures, such as 6 inches=1 mile, meaning that 6 inches on the map represent 1 mile on the ground. From this, it is easy to get the RF, thus:

$$\begin{aligned}\frac{6 \text{ inches}}{1 \text{ mile}} &= \frac{6 \text{ inches}}{1 \text{ mile} \times 5,280 \text{ feet} \times 12 \text{ inches}} \\ &= \frac{6 \text{ inches}}{63,360 \text{ inches}} = \frac{1}{10,560} = \text{RF}.\end{aligned}$$

(3) By a graphical scale drawn on the map, which shows ground distances in their usual units, such as miles, thousands of yards, or hundreds of feet, as they appear on the map. A graphical scale is easily made if one knows the RF of the map. Thus suppose the RF is 1:5,000 and a graphical scale to read to 1,000 yards is desired. Since any distance on the map is 1/5000 of the same distance on the ground, 1,000 yards on the map will be as follows:

$$\frac{1,000 \text{ yards}}{5,000} = \frac{1 \text{ yard}}{5} = 0.2 \text{ yard} = 0.2 \text{ yard} \times 36 \text{ inches} = 7.2 \text{ inches},$$

that is, one 1,000-yard division of the scale will be 7.2 inches long. This can be divided into 10 equal parts, each of which will represent 100 yards. (See fig. 144 for examples of graphical scales.)

Q. Why is it necessary to have maps of different scales?—A. The scale of a map must be large enough to show the particular features about which information is needed. Thus, a map showing the positions of all buildings and streets in a town must be of much larger scale than a map intended only to show the size and positions of the various counties in a State. A small-scale map is one which shows a large area in a small space. Thus, 1 inch=100 miles would be a very small scale map on which very little detail could be shown. A map on a scale of 1 inch=25 feet would be a very large scale map on which individual trees could be shown in their exact positions. The first map could be used by a general planning a large campaign, the second by an architect laying out a plan of a house and grounds.

Q. What determines the proper scale of a map?—A. It should be just large enough to show the detail necessary to serve the purpose for which it is to be used.

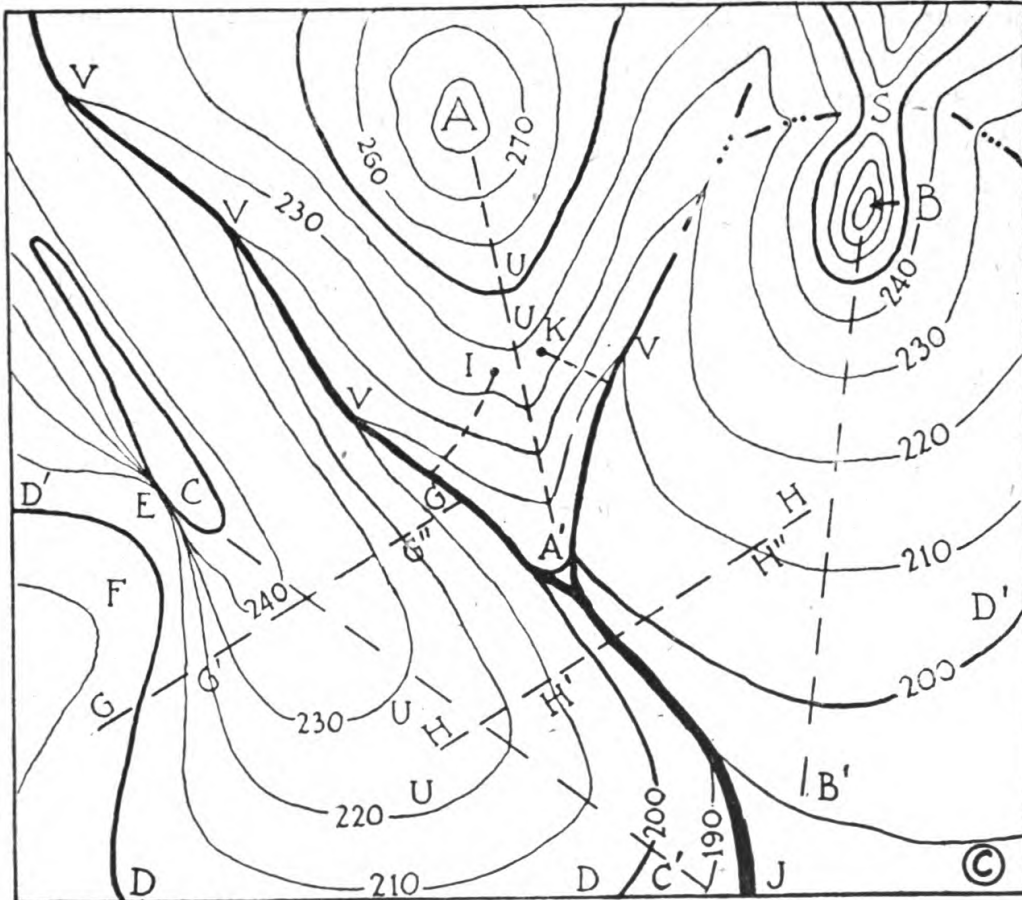
Q. How is direction determined on a map?—A. By referring to an arrow on the map which points due north. It is called the meridian.

Q. How is direction measured and indicated on a map?—A. By azimuth as in gunnery. Azimuth on a map is measured from the north point of the meridian, clockwise around the horizon. It is measured in degrees, minutes, and seconds, or in mils.

Q. What are the cardinal points of direction, and what are their azimuths?—A. North, east, south, and west. Moving clockwise

around the horizon: north, the origin, is azimuth  $0^{\circ}$ ; east is azimuth  $90^{\circ}$ ; south is azimuth  $180^{\circ}$ ; west is azimuth  $270^{\circ}$ .

Q. What is meant by orienting a map?—A. Placing the map in such a position that the meridian or arrow on the map points to north on the ground. Every line on the map will then be parallel to the



A, B. Hilltops or peaks.  
C. Ridge.  
DD. Contours close on themselves.  
E. Cliff.  
AA'. Uniform slope.  
BB'. Concave slope.  
CC'. Convex slope.

IG. Line of steepest slope.  
B. Steep slope.  
B'. Gentle slope.  
S. Saddle.  
UU. Hill contours.  
VV. Valley contours.  
A'. Stream junction.

FIGURE 142.—Typical ground forms as shown by contours.

line on the ground which it represents, and all the features on the map will be in the same relative positions as the actual objects on the ground.

Q. What is elevation?—A. The elevation of any point is its vertical height in feet above some level, usually sea level.

**Q.** How is elevation indicated on a map on a flat piece of paper?—  
**A.** By means of contours.

**Q.** What is a contour?—**A.** An irregular line joining all points at the same elevation. A contour is thus a level or horizontal line.

**Q.** How are contours separated vertically?—**A.** By some definite interval, such as 5, 10, 20, 50, or 100 feet, depending on the scale of the map and the nature of the ground. This constant interval is known as the vertical interval or contour interval of the map. Certain contours are numbered with their height (in feet) above sea level.

**Q.** Do contours show the ground forms, such as hills, valleys, and ridges?—**A.** Yes. When one has become familiar with them they show accurately all the forms of nature.

**Q.** Mention briefly the principal characteristics of contours. **A.**—

(1) A contour is a horizontal line joining points of equal elevation.

(2) Contours are spread at uniform vertical intervals.

(3) Every contour is a continuous closed curve. (It may not close within the limits of the map.)

(4) There may be any number of separate contours of the same elevation.

(5) A small, closed contour indicates either a hilltop or a depression.

(6) Contours never touch or cross each other except in the case of a vertical or overhanging cliff.

(7) Contours are at right angles to the lines of steepest slope.

(8) The horizontal spacing of contours indicates the degree of slope, steep if they are close together, gentle if they are far apart. They also indicate the kind of slope, uniform, concave, or convex.

(9) Valley contours are usually of V shape, and hill or ridge contours of U shape.

(10) Adjacent contours resemble each other.

**Q.** How is the elevation of a point between two contours determined?—**A.** By its relative distance from the contours on either side. Thus, in figure 144, the elevation of the number "46" is about 527 feet.

**Q.** Point out the characteristic ground forms in figure 142 and explain how they are shown by the contours.—**A.** See figure 142.

**Q.** What is a slope?—**A.** The inclination of ground to the horizontal. The slope of a road is called its grade.

**Q.** How can one determine the average grade of a length of road from a contoured map?—**A.** Measure the horizontal distance along the road in feet, using the scale of the map. Find from the contours the difference in elevation between the two ends. The difference in elevation of the two ends, divided by the length of the road (both in feet), will give the average grade in percent.

*Q.* How is a steep grade indicated on a map?—*A.* By contours close together, showing a considerable change of elevation in a short distance.

*Q.* What is a profile?—*A.* It is a section of the ground as it would appear if it were sliced vertically with a huge knife.

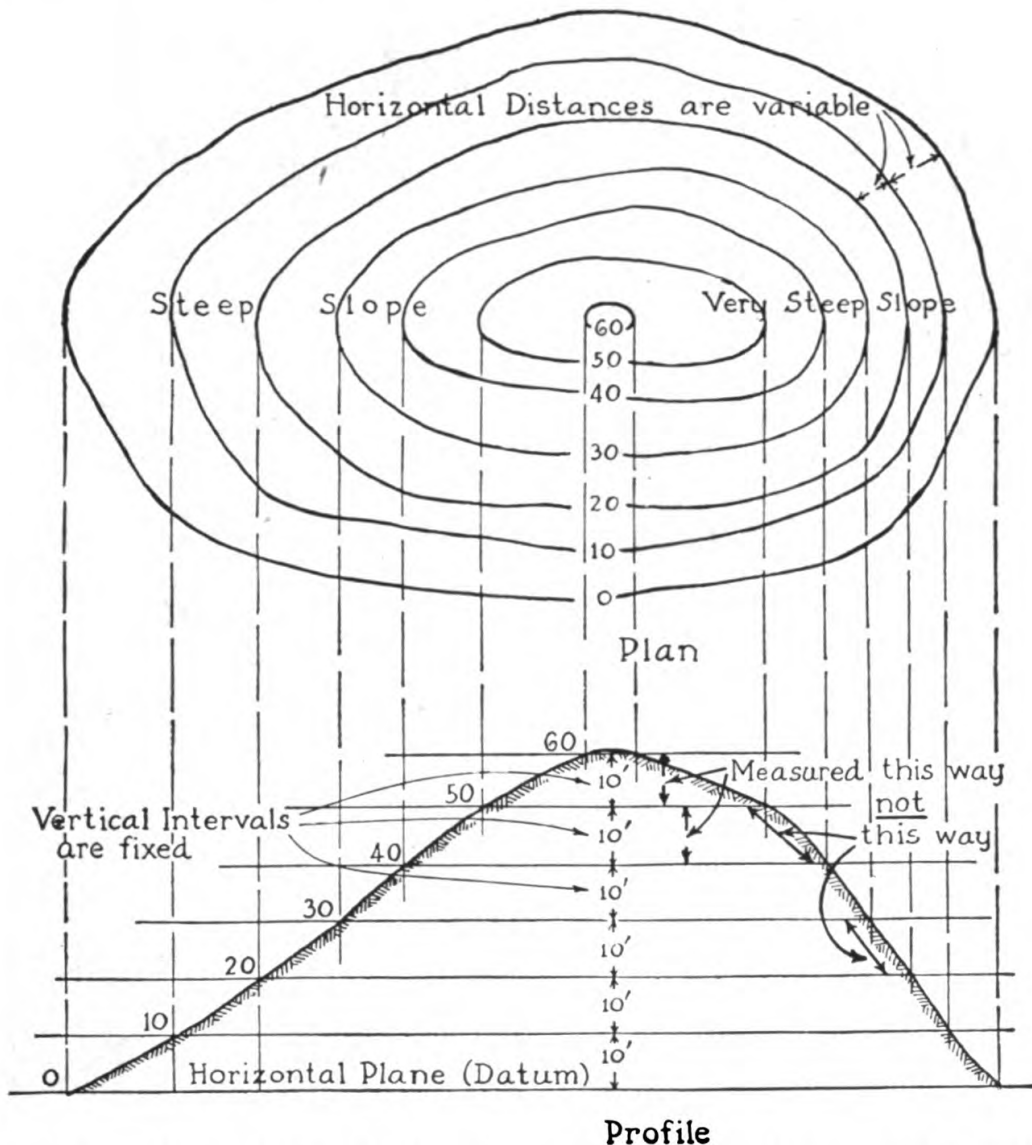


FIGURE 143.—Plan and profile of a hill. (Contours are the lines that would be left on the ground by successive horizontal slices 10 feet thick.)

*Q.* Give a simple method of making a profile.—*A.* To make a profile of the hill shown in figure 143, along the line of the words "Steep slope, Very steep slope" draw a number of parallel lines at uniform intervals, as in the lower figure, numbering them at 10-foot intervals from 0 to 60 feet (the limiting elevations of the hill). Mark each point where a contour cuts the line "Steep slope," and

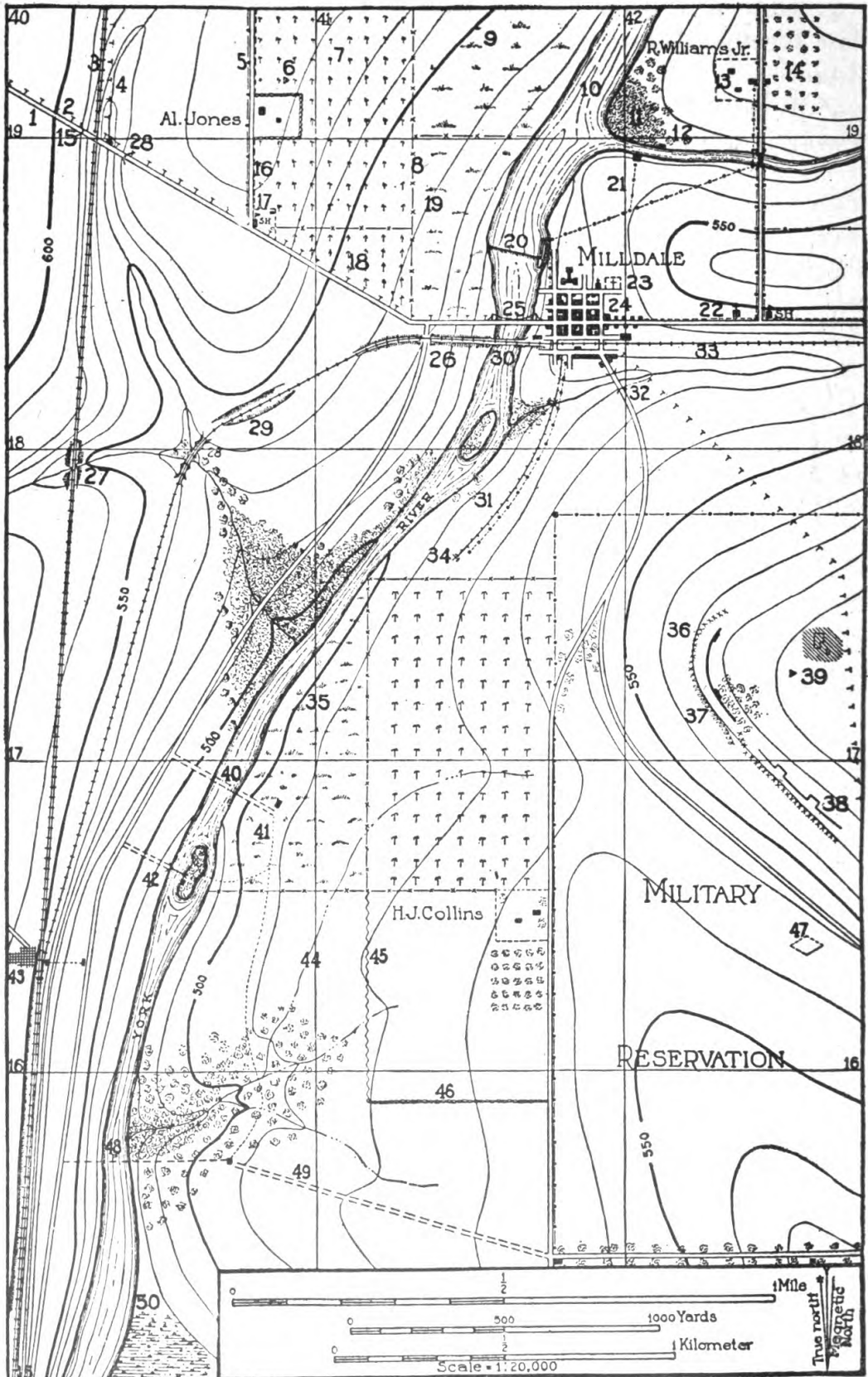


FIGURE 144.—Conventional signs.

*Numerical key*

1. Good motor road.
2. Telephone or telegraph line.
3. Double-track standard-gage railroad.
4. Stream or creek (blue on a four-color map).
5. Fence, smooth wire.
6. Triangulation point or primary traverse station.
7. Cornfield.
8. Fence, barbed wire.
9. Tall, tropical grass.
10. River (blue on a four-color map).
11. Woodland (deciduous trees).
12. Lone trees.
13. Buildings in general.
14. Orchard.
15. Railroad crossing, railroad beneath.
16. Fence of any kind (or board fence).
17. Schoolhouse.
18. Cultivated field, sugarcane.
19. Grassland in general.
20. Dam.
21. Electric power transmission line.
22. Church.
23. Cemetery.
24. City, town, or village.
25. Bridge, suspension.
26. Railroad crossing, railroad above.
27. Fill.
28. Bridge, steel.
29. Cut, railroad.
30. Bridge, truss, for standard-gage railroad.
31. Narrow-gage railroad.
32. Bridge, highway.
33. Railroad, single-track, standard-gage.
34. Mine or quarry of any kind (or open cut).
35. Pasture or grassland in general.
36. Wire entanglement.
37. Low or concealed entanglement.
38. Trenches (dotted when proposed).
39. Demolitions.
40. Ford, general symbol for vehicle ford.
41. Good pack trail or footpath.
42. Bridge, foot.
43. City, town, or village (generalized).
44. Intermittent stream.
45. Worm fence.
46. Stone fence.
47. Tank trap.
48. Equestrian ford.
49. Road, poor motor or private.
50. Marsh in general.

*Alphabetical key*

|   |    |
|---|----|
| Bridge, foot                                    | 42 |
| Bridge, highway                                 | 32 |
| Bridge, highway, made of steel                  | 28 |
| Bridge, suspension                              | 25 |
| Bridge, truss                                   | 30 |
| Buildings in general                            | 13 |
| Cemetery  | 23 |
| Church  | 22 |
| City, town, or village (generalized)            | 43 |
| Combination showing city, town, or village      | 24 |
| Crossing, railroad (railroad above)             | 26 |
| Crossing, railroad (railroad beneath)           | 15 |
| Cultivated field, corn                          | 7  |
| Cultivated field, sugarcane                     | 18 |
| Cut   | 29 |
| Dam   | 20 |
| Demolitions                                     | 39 |
| Electric power transmission line                | 21 |
| Fence, barbed wire                              | 8  |
| Fence of any kind (or board fence)              | 16 |
| Fence, smooth wire                              | 5  |
| Fence, stone                                    | 46 |
| Fence, worm                                     | 45 |
| Fill  | 27 |
| Ford, equestrian                                | 48 |
| Ford, for vehicles                              | 40 |
| Grass, tall tropical                            | 9  |
| Grassland in general                            | 19 |
| Marsh in general                                | 50 |
| Mine or quarry of any kind (or open cut)        | 34 |
| Orchard   | 14 |
| Pasture or grassland in general                 | 35 |
| Railroad, double-track, standard-gage           | 3  |
| Railroad, narrow-gage                           | 31 |
| Railroad, single-track, standard-gage           | 33 |
| River (blue on a four-color map)                | 10 |
| Road, good motor                                | 1  |
| Road, poor motor or private road                | 49 |
| Schoolhouse                                     | 17 |
| Stream or creek (blue on a four-color map)      | 4  |
| Stream or creek, intermittent                   | 44 |
| Tank trap                                       | 47 |
| Telephone or telegraph line                     | 2  |
| Trail or footpath                               | 41 |
| Trees, lone                                     | 12 |
| Trenches (dotted when proposed)                 | 38 |
| Triangulation point or primary traverse station | 6  |
| Wire entanglement                               | 36 |
| Wire entanglement (low or concealed)            | 37 |
| Woodland (deciduous trees)                      | 11 |

project these points vertically down to the correspondingly numbered lines. Join the points thus found by a line. It will be the contour of the hill on the line "Steep slope."

*Q.* What are conventional signs?—*A.* They are the symbols used by map makers to show the various features of the terrain. As nearly as practicable they resemble or suggest the features they are intended to show.

*Q.* Point out and name the conventional signs shown in figure 145.—*A.* See figure 144.

*Q.* What colors are used on standard topographical maps and what do these colors mean?—*A.* Colors are used to show certain classes

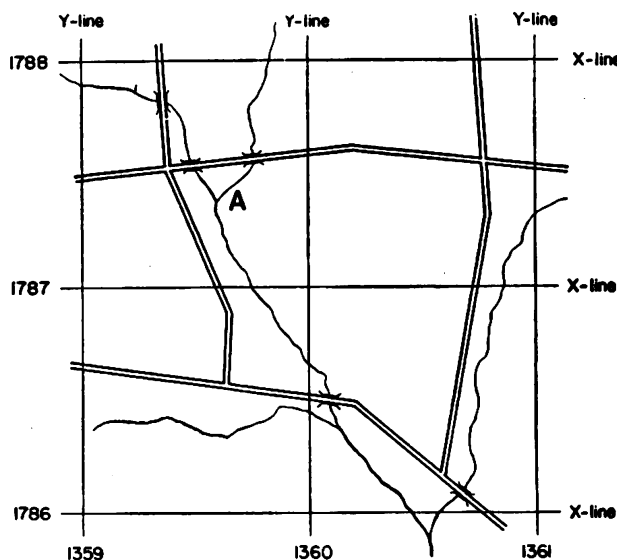


FIGURE 145.—Rectangular coordinates. 1,000-yard grid printed upon a terrain map. (1 : 20,000 scale.) (Not reproduced to scale.)

of features. On the standard topographical map they show the following:

- (1) *Black.*—All artificial features, such as houses and roads.
- (2) *Blue.*—All water, such as streams, ponds, and lakes.
- (3) *Green.*—Vegetation, such as woods and grassland.
- (4) *Brown.*—The ground forms as shown by contours.

**160. Location of position by coordinates.**—*Q.* How are military maps divided?—*A.* Into squares 1,000 yards on a side by two sets of parallel lines, one of these sets being at right angles to the other. (See fig. 145.)

*Q.* What is this system of lines or squares called?—*A.* A grid system, or system of rectangular coordinates.

*Q.* What is the use of this grid or coordinate system?—*A.* It is used to make it possible to describe and locate points on a map by referring their positions to the coordinate lines.

Q. What are the coordinate lines running from left to right called?—A. X-lines.

Q. What are the other coordinate lines called?—A. Y-lines.

Q. Describe the grid system for the continental United States.—

A. The country is divided into zones running north and south, each covering  $9^\circ$  of latitude. The central true meridians of adjacent zones are  $8^\circ$  apart, hence there is an overlap of  $1^\circ$  at the boundaries, included in both adjacent zones. The west longitudes of the central meridians of the zones are  $73^\circ$ ,  $81^\circ$ ,  $89^\circ$ ,  $97^\circ$ ,  $105^\circ$ ,  $113^\circ$ , and  $121^\circ$ . In each zone the Y-lines are all parallel to the central true meridian. The direction of the Y-line at any point is called grid north; it is the same as true north only at the center of the zone. The X-lines are perpendicular to the Y-lines, and so they are true east and west lines only at the center of the zone. In each zone the origin of coordinates, or zero point, is to the west and south of the zone, and hence all coordinates are positive. (See fig. 145.)

Q. What is the X-distance or X-coordinate of a point on a map?—

A. The distance of that point to the right of the origin of measurement measured along an X-line.

Q. What is the Y-distance or Y-coordinate of a point on a map?—

A. The distance of that point upward from the origin of measurement measured along a Y-line.

Q. What is the origin or point from which measurements are made?—A. A point off the map to the west and south. The distance from this origin, in thousands of yards, is indicated on each X-line and each Y-line.

Q. In order to locate a point on a map, what information is useful?—A. The X- and Y-coordinates of that point.

Q. In what order are the coordinates of a point always given?—

A. First the X-coordinate and then the Y-coordinate.

Q. How can their order be remembered easily?—A. Remember that in the alphabet X comes before Y, or remember the rule "Read right up."

Q. How can one X-line be distinguished from the other X-lines or one Y-line from the other Y-lines?—A. Each set of lines is numbered.

Q. How are the X-lines numbered?—A. In the left- and right-hand margins, increasing upwards from the bottom of the map.

Q. How are the Y-lines numbered?—A. Along the upper and lower margins, increasing from left to right of the map.

Q. Is the number of a coordinate line given in the margin of a map the full number of that line?—A. No. It is only a part of its full number.

*Q.* Are there any coordinate lines on a map that have their full numbers given?—*A.* Yes. The first X-line at the bottom of the map and the first Y-line at the left of the map.

*Q.* Explain in detail how to read the coordinates of any point on a gridded map.—*A.* The coordinates of any square in the grid system are the X- and Y-coordinates of the lower left-hand (south-west) corner of the square. The coordinates of the lower left-hand square in figure 146 are (1,364,000–1,790,000) but are usually written (1364–1790), it being understood that each number represents thousands of yards. These coordinates also locate to the nearest thousand yards any point in the lower left-hand square of figure 146. To locate a point more closely, assume that each side of the square in question is divided into 10 equal parts, each of which represents 100

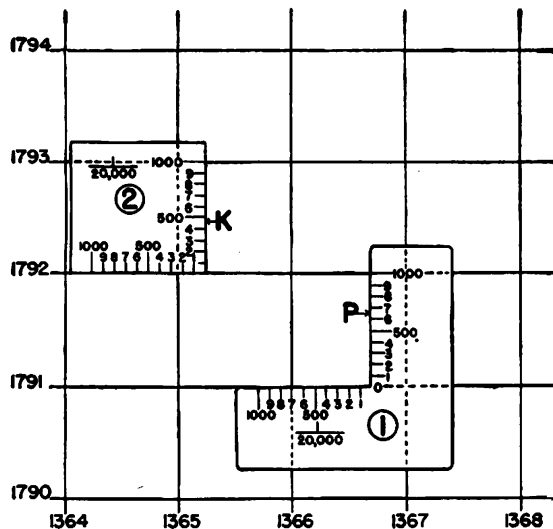


FIGURE 146.—To plot the position of a point with a coordinate scale on a terrain map (1 : 20,000 scale) having a 1,000-yard grid. (Not reproduced to scale.)

yards. Then the coordinates of the center of the lower left-hand square would be expressed as (1364.5–1790.5), which locates the center to the nearest hundred yards in each direction. The method may be further refined to read to the nearest 10 yards.

*Q.* What is a coordinate scale? Explain its use.—*A.* A coordinate scale is a right-angled ruler made of thin metal, celluloid, or other material with scales on it equal in length to the grid interval of the map being used (fig. 146). To plot any point on the map, for instance the point P of which the coordinates are given as (66.70–91.65), place the coordinate scale on the map in position ① as shown in figure 146. The position of P can be marked at once with a pin or sharp pencil. It should be noted here that the first two numbers of the coordinate expression (1366.70–1791.65) have been dropped because they are common to all points in the section of map under

consideration. The process of reading the coordinates of a point appearing on the map is the reverse of the method given for plotting a point on the map.

*Q.* How many norths are indicated on an artillery map?—*A.* Three. True north, magnetic north, and grid north. (See fig. 144.)

*Q.* Define each. *A.*—

(1) True north is a geographic north, or the direction of the north pole.

(2) Magnetic north is the direction in which the compass points when used in the area covered by the map. The angular difference between true north and magnetic north is called the magnetic declination.

(3) Grid north is the direction in which the Y-lines of the coordinate system point.

*Q.* When indicating direction which north is generally used?—*A.* Grid north.

*Q.* On what kind of maps is such a system of coordinates usually found?—*A.* On topographical maps.

*Q.* What type of maps are often used to cover harbors and water areas?—*A.* Coast and Geodetic Survey maps.

*Q.* Do these maps generally have a system of grid coordinates?—*A.* No. There is, however, a local system of grid coordinates placed on these maps so points can be located in the same way.

*Q.* What do these maps show?—*A.* Coast line, channels, depths of water, location of lights, channel markers, and certain permanent features of the terrain along the shore.

(In addition, the candidate should be required to give the coordinates of certain points on a map.)

**161. Following route indicated on map.**—*Q.* How is a route, selected from a map, usually indicated?—*A.* It is indicated by naming successive points along the route that can easily be identified locally.

*Q.* How are the best roads identified on the ground?—*A.* Usually they will be paved, and will be wider, straighter, and have easier grades than secondary roads. If not paved they will at least be wide and show signs of traffic. They usually have telegraph or telephone lines running parallel to them. Except in very sparsely settled country the principal roads will also be indicated by signposts at intersections and Federal and State numbers, which are shown on commercial route maps.

*Q.* What points along a route are most easily identified? *A.*—

(1) Large towns.

(2) Villages.

- (3) Important crossroads or junctions.
- (4) Crossings of large streams.
- (5) Railroad crossings.
- (6) Crests of important hills or ridges.
- (7) Passes or gaps through lines of hills.

Q. How may an indicated route be traced on a map?—A. By locating in succession the towns, crossroads, and other important points named.

Q. How are crossroads and road junctions indicated on a map?—A. By numbers sometimes followed by a letter as 423 or 423-A.

Q. How would crossroad 418-A be written in indicating a route? Road junction 403?—A. CR 418-A. RJ 403.

Q. To what do the numbers in the previous answer refer?—A. To the elevation of the crossroad or road junction.

Q. In case a crossroad or junction is not plainly marked on the map, how would it be indicated?—A. By its coordinates, as CR (4365.5-6427.3) or RJ (7295.4-8665.4).

(The candidate should be able to trace out on a map a route that has been indicated to him.)

**162. Data as to roads, bridges, fords, grades, and swamps.—**

Q. What information concerning a road can usually be obtained from a good topographical map? A.—

- (1) The distance between any two points.
- (2) Whether or not the road is paved, and often the kind of pavement.
- (3) The width of the road, that is whether narrow, wide, or quite wide.
- (4) The steepness and length of important grades.
- (5) The stream crossings, whether bridges, fords, or ferries, and sometimes the kind and principal dimensions of bridges; width, depth, nature of bottom, and velocity of current in the case of fords; and the kind of ferry.

Q. What is usually the most critical question in the selection of a route?—A. The stream crossings.

Q. Explain how to decide the question as to whether a certain bridge was safe for the transport accompanying an organization (candidate's).—A. Reports on the practicability of all bridges should be secured in advance if possible. If not, the following observations will indicate the safety of bridges in most cases.

- (1) Bridges on important routes habitually carry heavy commercial trucks and busses, moving at high speed, and are therefore safe for artillery transport moving slowly.

(2) If a bridge is massive, and reasonably new, or apparently in good condition as to flooring, paint, etc., it is probably safe.

(3) Bridges may be compared with similar bridges that have been crossed. If they look too light or appear to be of older design than other bridges, they should be regarded with suspicion.

(4) If there is any chance that the enemy may have tampered with a bridge, its abutments, piers, flooring, and truss members or cables should be examined to make sure they are intact.

(5) If in doubt about any bridge, send across some lighter vehicle and watch the bridge as it crosses. If there is no excessive sway or vibration the bridge is probably safe for the next heavier load. Send loads across one at a time and at very slow speed.

*Q.* How may the practicability of a ford be determined?—*A.* Note the swiftness of the current. Send a line of men to wade across, preferably barefoot, to determine the depths, nature of the bottom, and whether the banks are steep or slippery or both. Some of the lighter vehicles may then be sent across, and these can assist the heavier vehicles by pulling them out on the far side if necessary.

*Q.* In case a bridge or ford proves impassable what should be done?—*A.* Detour to another crossing.

*Q.* What, in general, can one say as to the practicability of routes?—*A.* That, in general, important main routes are practicable for artillery transport; that in the case of less important routes it is desirable to have a reconnaissance made in advance by competent experts; that any route that lacks a bridge at an important crossing is of doubtful practicability.

(The candidate should be required to examine a route shown on a map, to give all the information concerning it that can be obtained from the map, and his opinion as to the practicability of the route.)

## SECTION IV

### ELEMENTARY PRINCIPLES OF ELECTRICITY, MAGNETISM, AND INDUCTION

|                              |               |
|------------------------------|---------------|
| Electricity.....             | Paragraph 163 |
| Magnetism and induction..... | 164           |

**163. Electricity.**—*Q.* What is the term used to designate the pressure that causes a current of electricity to flow?—*A.* It is called electromotive force, potential, or more commonly, voltage.

*Q.* What is a volt?—*A.* The unit for measuring electromotive force.

*Q.* What is an ampere?—*A.* A unit for measuring the magnitude (amount) of an electric current.

*Q.* What is resistance? What is the unit of resistance?—*A.* Resistance is the opposition offered by a conductor to the flow of an electric current. The unit of resistance is the ohm.

*Q.* What is Ohm's law?—*A.* The electric current in a conductor equals the voltage applied to the conductor divided by the resistance of the conductor.

*Q.* What are three simple formulas by which Ohm's law may be expressed? *A.*—

$$(1) \text{ Amperes} = \frac{\text{volts}}{\text{ohms}} \left( I = \frac{E}{R} \right)$$

$$(2) \text{ Volts} = \text{amperes} \times \text{ohms} \quad (E = IR)$$

$$(3) \text{ Ohms} = \frac{\text{volts}}{\text{amperes}} \left( R = \frac{E}{I} \right)$$

*Q.* What are the common sources of electrical power?—*A.* Batteries, generators, and magnetos.

*Q.* What are the two principal types of batteries?—*A.* Storage (wet) batteries and dry batteries.

*Q.* What is a conductor?—*A.* Any substance offering very little resistance to the flow of electric current is known as a conductor.

*Q.* What is insulation?—*A.* Insulation is any substance that restricts or prevents the flow of an electric current. Rubber, porcelain, enamels, linen, and paper are used extensively for insulation.

*Q.* What is an insulated conductor?—*A.* A conductor covered with insulation to prevent grounds or short circuits.

*Q.* What is direct current?—*A.* A current flowing constantly in one direction.

*Q.* What is alternating current?—*A.* A current flowing first in one direction, then in the opposite direction, changing direction many times every second.

*Q.* What is a cycle?—*A.* A complete change or alteration from a current in one direction to the opposite direction and back to the original direction, is known as a cycle. The frequency of an alternating current means the number of cycles that occur in a second, as 25 (sometimes employed on power lines) or 60 (commonly employed).

*Q.* What is a circuit?—*A.* A circuit is the complete path through which current can flow, including the source of power, the conductors, and electrical devices such as lamps, bells, or motors.

*Q.* What is a closed circuit?—*A.* A continuous path with a return to the source of power.

*Q.* What is an open circuit?—*A.* An incomplete or broken circuit in which no current can flow.

*Q.* What is a switch?—*A.* A mechanical means by which an electric circuit is closed or opened.

*Q.* What kind of current is obtained from a battery?—*A.* Direct current only.

*Q.* What are the poles or terminals of a battery?—*A.* The two connections between the battery and its circuit. They are known as the positive (+) and negative (−) poles. The positive pole is that from which the electrical current flows out of the battery and the negative pole the one by which it returns again to the battery.

*Q.* Which is the positive and which the negative pole of a dry cell?—*A.* The carbon is the positive pole and the zinc is the negative pole.

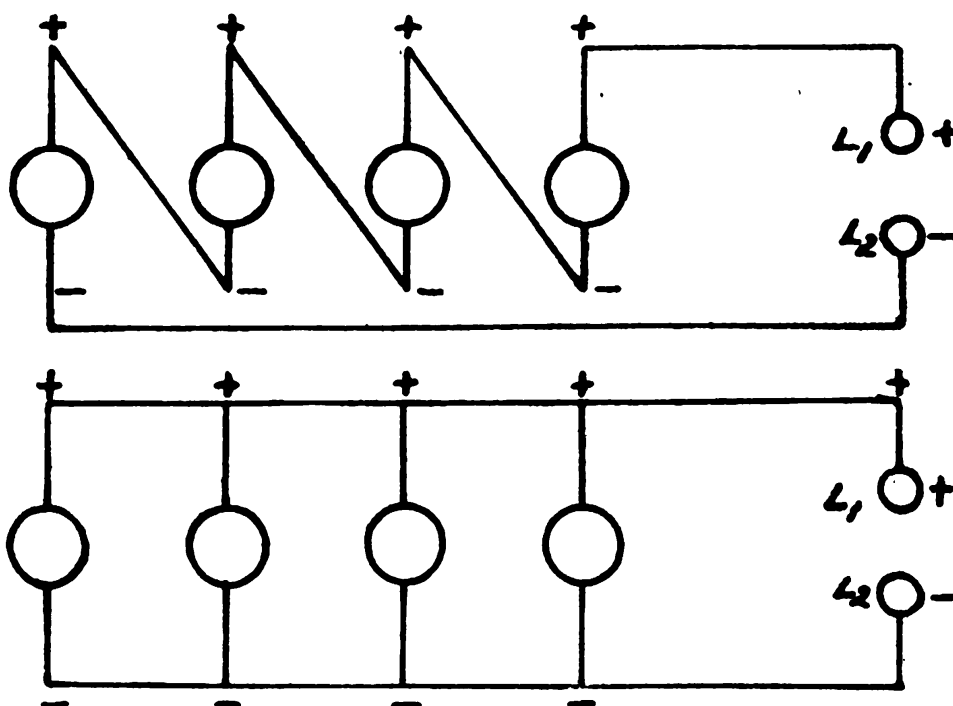


FIGURE 147.—Upper: Batteries connected in series. Lower: Batteries connected in parallel or multiple.

*Q.* What is the voltage of a dry cell?—*A.* About  $1\frac{1}{2}$  volts.

*Q.* What is the voltage of one cell of a storage battery?—*A.* About 2 volts.

*Q.* What is meant by the expression “in series”? Show how to connect a battery in series.—*A.* See figure 147, upper. The cells of a battery are said to be in series when the positive terminal of each cell is connected to the negative terminal of the next cell. The cells are thus in tandem, the entire current generated by all of them passing through each cell.

*Q.* What is the voltage of a battery with the cells connected in series?—*A.* The sum of the voltages of the separate cells. Thus, if

each cell has a voltage of 2, a battery of 4 cells connected in series has a voltage of  $2 \times 4 = 8$ .

*Q.* What is the current of a battery with the cells connected in series?—*A.* The average current of the separate cells of a battery. Thus, if each cell produces a current of 20 amperes, a battery of 4 cells connected in series will also produce a current of 20 amperes.

*Q.* Assume that each of the cells in figure 147, upper, is a dry cell with a voltage of  $1\frac{1}{2}$  volts. What is the voltage of the combination?—*A.* The electromotive force or voltage of the combination of cells will be 6 volts ( $4 \times 1\frac{1}{2}$ ).

*Q.* What is meant by the expression "in parallel" or "in multiple"? Show how to connect four batteries in parallel.—*A.* See figure 147, lower. Batteries are said to be in parallel when all their positive terminals are connected to a common point ( $L_1$ ), and all their negative terminals to another point ( $L_2$ ). The batteries are thus abreast, a portion only of the resultant current passing through each battery.

*Q.* What is the voltage of a battery with the cells connected in parallel?—*A.* The average voltage of the separate cells of the battery. Thus, if the voltage of each cell is 2, a battery of 4 cells connected in parallel will also have a voltage of 2.

*Q.* What current will be obtained from a battery with the cells connected in parallel?—*A.* The sum of the currents of the undivided cells. Thus, if each cell produces a current of 20 amperes, a battery of 4 cells connected in parallel will produce a current of  $4 \times 20 = 80$  amperes.

*Q.* Assume that each of the cells in figure 147, lower, is a dry cell with a voltage of  $1\frac{1}{2}$  volts. What is the voltage of the combination?—*A.* The electromotive force or voltage of the combination of cells will be  $1\frac{1}{2}$  volts.

*Q.* How is the capacity of a storage battery stated?—*A.* In ampere-hours.

*Q.* What is an ampere-hour?—*A.* A steady current of 1 ampere flowing for 1 hour.

*Q.* What is meant by saying that a battery has a capacity of 60 ampere-hours?—*A.* It means that it can furnish 60 amperes for 1 hour or 1 ampere for 60 hours.

*Q.* What is electrolyte?—*A.* The fluid content of a wet (storage) battery.

*Q.* What care is necessary to preserve a storage battery? *A.*—

(1) Refill the battery with distilled water so that the plates are always covered with electrolyte.

(2) Never allow the battery to discharge fully.

(3) Do not add sulfuric acid to the battery.

- (4) Keep battery always in an upright position.
- (5) Never leave a battery connected when current is not required.
- (6) Keep battery fully charged as much as possible.
- (7) Handle the battery with care to prevent breaking the container.
- (8) Treat terminals with vaseline or grease to prevent corrosion.
- (9) Keep battery, battery room, and all accessories clean.

**Q.** Why is it necessary to use distilled water in a storage battery?—

**A.** Because ordinary water usually contains minerals, which are acted upon by the acid and form combinations which soon render the battery useless.

**Q.** How is it determined whether a storage battery is charged or discharged?—**A.** By measuring the specific gravity of the electrolyte (liquid) with a hydrometer. When fully charged the specific gravity is 1,280; when fully discharged, 1,150. A battery should never be discharged so that its specific gravity is below 1,200.

**Q.** What is the meaning of the term specific gravity as applied to an electrolyte?—**A.** It means the weight of the fluid as compared to the weight of an equal volume of water. The specific gravity of water is taken as 1,000.

**164. Magnetism and induction.**—**Q.** What is a permanent magnet?—**A.** A bar of iron or steel which possesses the property of attracting or repelling other pieces of iron or steel.

**Q.** What is an electromagnet?—**A.** A coil of wire through which a current is flowing. Its magnetism is increased by placing it about a core of soft iron.

**Q.** Explain briefly the principle of electromagnetic induction. **A.**—

(1) If an electric circuit is moved in the vicinity of a magnet, or if a magnet is moved in the vicinity of an electric circuit, a current of electricity is set up or induced in the circuit. This is the principle used in the generator and magneto.

(2) If two electric circuits are placed close to each other, any variation in the current passing through one circuit will set up or induce a current in the other circuit. This principle is used in the induction coil and transformer.

**Q.** Explain the construction of an induction coil.—**A.** To construct an induction coil, two separate coils of insulated wire are wound spirally about an iron core. Each coil forms a circuit by itself. One of the coils, called the primary, consists of a relatively small number of turns of coarse wire. The other coil, called the secondary, consists of a relatively large number of turns of fine wire.

**Q.** Explain the operation of an induction coil.—**A.** An electric current is passed through the primary coil. If this current is varied

or changed in any way, either by turning it on or off, increasing or decreasing its intensity, or reversing its direction, an induced current will be set up in the secondary coil which lasts as long as the change of current in the primary coil continues.

*Q.* How can the voltage in the secondary coil of an induction coil be determined?—*A.* The voltage (EMF) of the current induced in the secondary coil is approximately equal to the voltage in the primary coil, multiplied by the ratio between the number of turns in the two coils. Thus if the number of turns in the primary coil is 8 and in the secondary coil 96, and the voltage in the primary coil is 10, the voltage of the induced current in the secondary coil will be  $10 \times 96 \div 8 = 120$  volts.

*Q.* Will an alternating current passing through the primary coil induce a current in the secondary coil?—*A.* Yes, because the voltage in the primary coil is constantly changing in direction and intensity, which is the condition necessary to induce a current in the secondary.

## SECTION V

### AMMUNITION—ADVANCED

|   |               |
|---|---------------|
| Procuring, handling, and storage of ammunition----- | Paragraph 165 |
| Ammunition records, reports, and forms-----         | 166           |

**165. Procuring, handling, and storage of ammunition.—***Q.* What regulations govern the handling of ammunition?—*A.* TM 9-2900, AR 30-1270, AR 30-955, AR 700-10, and such local regulations as may be prescribed; for example, many localities require a special placard or flag to be displayed.

*Q.* Where may detailed regulations prescribing rules governing the transportation of explosives be obtained?—*A.* From the Interstate Commerce Commission through The Quartermaster General or the Chief of Ordnance. These regulations permit the Government to prescribe their own shipping regulations, marking, packing, and storing but the War Department regulations comply in general with the Interstate Commerce Commission regulations.

*Q.* How are the necessary labels obtained?—*A.* On requisition through the Quartermaster General.

*Q.* What responsibilities must the shipping officer assume?—*A.* That all regulations are complied with. In case of fire or accident the shipping officer is responsible.

*Q.* May explosives be carried as a deck load on Army transport?—*A.* No.

**Q.** When transporting explosives by truck what procedure shall be followed? **A.**—

- (1) Comply with Government and local regulations.
- (2) Contact local authorities and select safe routes.
- (3) Take every precaution against fire.

**Q.** What precautions must be taken against fire? **A.**—

(1) Inspect trucks daily for wiring, lights, brakes, gasoline tanks, and lines.

- (2) Keep vehicle and engine clean.
- (3) Permit no smoking.
- (4) Keep safety matches in a metal container in tool box.
- (5) Provide each truck with a sand box—3 cubic feet—and a shovel.
- (6) Instruct all drivers in fire fighting. Ammunition requires considerable heat before it will explode, and a fire, if discovered in time, can usually be put out with safety.

- (7) Do not transport detonating agents with other explosives.
- (8) Lay boards over all iron parts of the truck.
- (9) See that load is well braced and stayed and is covered with a tarpaulin to prevent fire by sparks.

**Q.** When ammunition is being transported by convoy, what precautions should be taken? **A.**—

(1) Keep a safe distance between trucks to avoid danger of collision.

- (2) Stop once each hour and inspect the load.
- (3) Do not stop in populous areas.
- (4) Permit no unauthorized riders.
- (5) If a truck breaks down, transfer its load to another truck. Do not attempt to tow. Leave a guard with the truck until the load can be transferred.

(6) In case of fire, move all other vehicles to a safe distance and post a guard at a safe distance from the fire to ward off other traffic.

**Q.** How is artillery ammunition packed in a truck for transportation?—**A.** Laid on its side parallel to the sides of the truck. If more than one layer is to be placed in the truck, strips of planking should be laid to protect the rotating bands.

**Q.** Under whose supervision should ammunition be handled?—**A.** Under a competent person who understands thoroughly the hazards and risks involved.

**Q.** Name some hazardous explosives.—**A.** Detonators, bulk explosives, and smokeless powder.

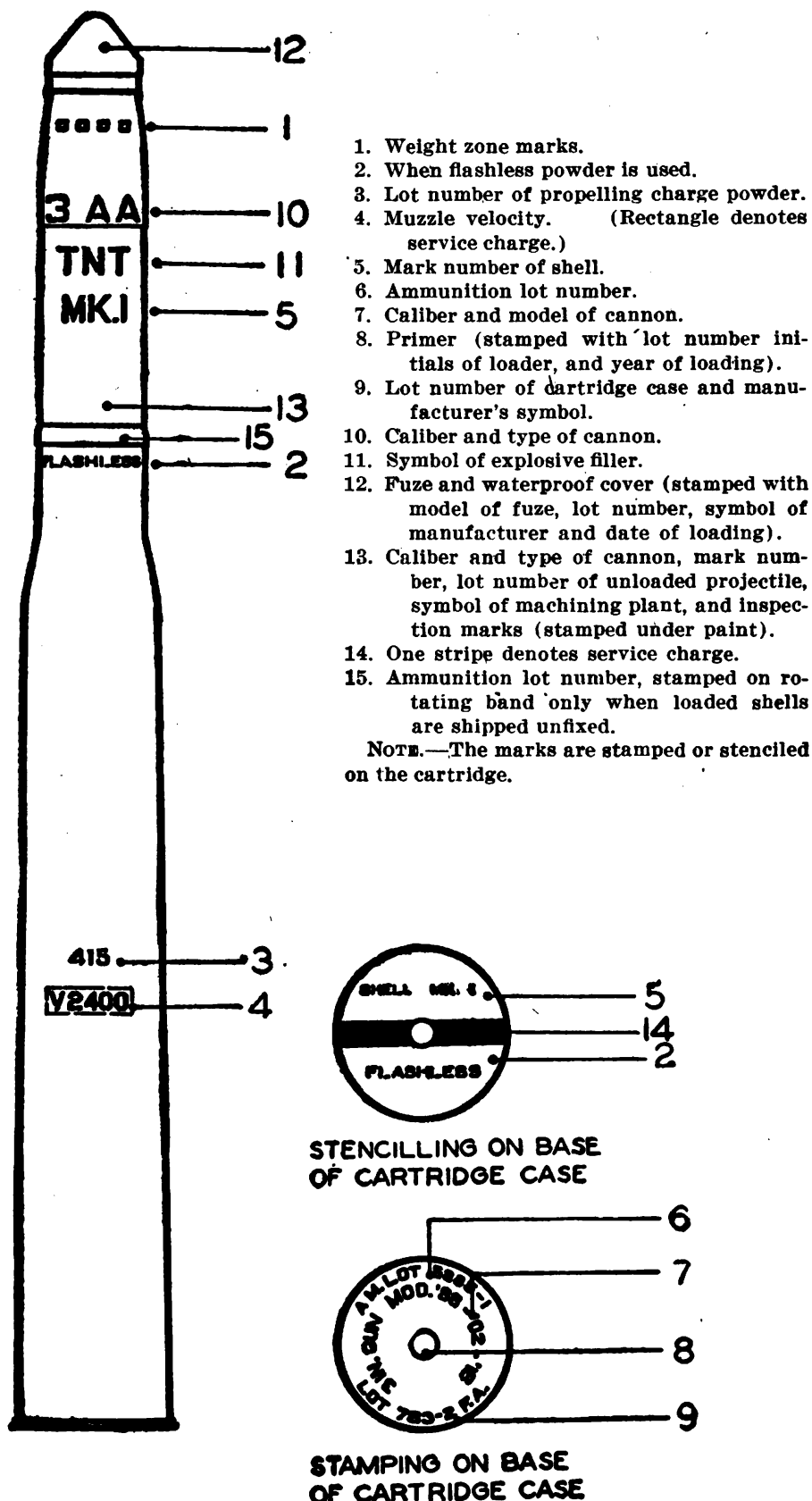


FIGURE 148.—Marking for 3-inch antiaircraft high-explosive, fixed ammunition.

Q. In case explosives are spilled from a container, what should be done?—A. All work must be stopped until the explosives have been swept up and the area has been neutralized.

Q. Where may damaged containers be repaired?—A. In the open, or in a building especially designated for this purpose, at least 100 feet from the magazine, boat, or truck containing ammunition.

Q. If ammunition must be stored outside, what must be done?—A. It must be protected from the direct rays of the sun in such a way that air may freely circulate through the pile.

Q. What ammunition may be stored in a battery storeroom?—A. The small quantity of small-arms ammunition required for current use.

Q. Where must ammunition be stored?—A. In special magazines such as described in Technical Manuals.

Q. How is ammunition segregated in storage?—A. Ammunition is placed in neat, stable piles by lot number, and raised off the floor on 2-inch battens.

Q. How high may ammunition be piled?—A. This depends on the strength of the container, but piles should not exceed the height of the eaves in magazines.

Q. What does an acid odor in a powder magazine indicate?—A. Danger—powder is decomposing.

Q. What testing instruments are placed in powder and ammunition magazines? A.—

- (1) Maximum and minimum thermometer.
- (2) Hygrometer.
- (3) Litmus paper.

Q. How is air circulation provided in ammunition storage?—A. By dunnage or by cleats on the boxes.

Q. Where may small-arms ammunition be stored?—A. In any magazine or warehouse which offers good protection against the weather.

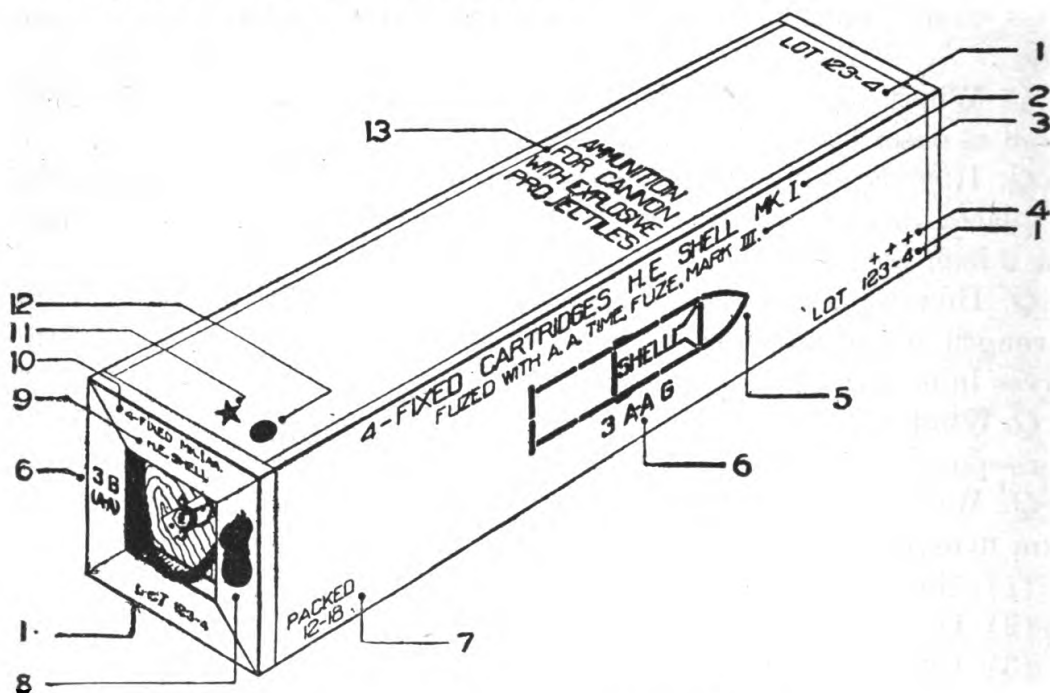
Q. In case of doubt of the condition of ammunition in storage, who is notified?—A. The local ordnance officer.

Q. How are allocations of ammunition obtained under field service conditions?—A. The munitions officer prepares a daily ammunition expenditure report which is sent to the regiment or next higher commander. In each higher headquarters the reports are consolidated. The corps commander sends in his consolidated report to the army. Based on these reports the army allocates ammunition to the corps, and so on down until the battalion is informed of how much ammunition it will get and when and where to go for it.

Q. What is fixed ammunition?—A. Ammunition in which the primer, propelling charge, and projectile are in one piece, all being contained in a metal cartridge or shell case. Thus all components of the round are loaded in the gun as a unit.

Q. What is separate loading ammunition?—A. Ammunition in which the projectile, powder charge, and primer are separate and are loaded separately into the gun.

Q. What types of AA ammunition are issued?—A. High-explosive shell and shrapnel. Both types are fixed ammunition, complete with fuze in place. The fuze is set at safe.



- |  |   |
|--|---|
| 1. Ammunition lot number.  | 8. Ordnance insignia.   |
| 2. Number of complete rounds, type, and mark number of projectile. | 9. Type of projectile.  |
| 3. Statement of fuze used.   | 10. Number of rounds and mark number of projectile.                               |
| 4. Weight zone marks.  | 11. Inspector's stamp.  |
| 5. Symbol of ammunition in box.                                    | 12. Name of place where packed.   |
| 6. Caliber and type of cannon.                                     | 13. To comply with I. C. C. regulations, both ends of container are marked alike. |
| 7. Month and year of packing.                                      |   |

FIGURE 149.—Container for high-explosive fixed ammunition for 3-inch antiaircraft gun.

Q. How is the packing box for 3-inch high-explosive antiaircraft ammunition marked?—A. See figure 149.

Q. How many 3-inch cartridges (high-explosive shell or shrapnel) are packed in one container?—A. Four in boxes, three in carton containers.

Q. How many 105-mm cartridges (practice or high-explosive shell) are packed in one container?—A. Two of either type.

Q. Where should ammunition dumps be located and how should ammunition be stored in them?—A. The dump should be located on

good roads, somewhat removed from congested highways, and should provide circulation and turn-around space for the trucks. Woods will give protection from aerial observation, but camouflage methods must be employed for protection in any event. The intervals between piles of ammunition should be ample to prevent destruction of the entire dump by explosion of a single projectile.

*Q.* How is 37-mm ammunition packed?—*A.* Twenty rounds are packed in a sealed, metal-lined packing box. Total weight of box and ammunition, 85 pounds.

**166. Ammunition records, reports, and forms.**—(Include their preparation, distribution, routing, and filing.) *Q.* How is ammunition obtained in peacetime?—*A.* Requisitions are submitted through the regimental munitions officer who submits a consolidated requisition on the post ordnance officer. When the requisition has been approved, the battalion munitions officer makes the necessary arrangements to draw the ammunition and deliver it to the batteries.

*Q.* What record of issue is sent to the regimental munitions officer?—*A.* A shipping ticket.

*Q.* What check must he make?—*A.* He checks it for quantity as listed and for condition.

*Q.* If the shipment does not agree with the shipping ticket, what does he do?—*A.* He submits an O. S. & D., W. D. Q. M. C. Form No. 445 (Over, Short, and Damaged Report).

*Q.* What receipts does the regimental munitions officer obtain on issuing ammunition?—*A.* When the battalion munitions officer distributes it he has each battery commander sign a memorandum receipt, and returns the receipt to the regimental munitions officer. Sometimes the regimental munitions officer issues ammunition direct to the batteries and takes their receipts.

*Q.* How does the firing battery commander secure credit for ammunition he has fired?—*A.* He submits a certificate of expenditure and is given credit for the amounts shown thereon, by the regimental munitions officer.

*Q.* What is the system of ammunition supply in the field during war?—*A.* Daily reports of ammunition expenditure are forwarded by the battalion munitions officer. This shows how much ammunition is left in the unit and indicates its rate of expenditure. Based on these reports, allocation of ammunition is made to the battalion which then draws it. Sometimes ammunition credits are issued for ammunition at a certain point, which can be drawn against as needed.

*Q.* What further records are necessary?—*A.* Receipts for the ammunition must be signed as drawn, but no further accountability is

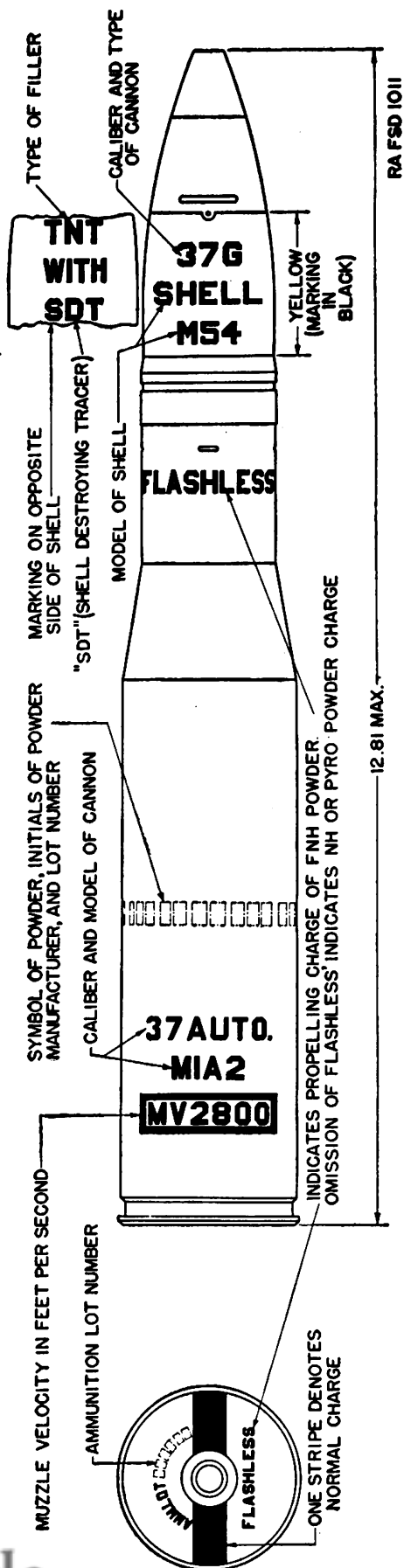


FIGURE 150.—Shell, fixed, high-explosive, M54, with SD tracer and PDF M56, 37-mm automatic gun M1A2.

required. As ammunition is such a vital need the responsibility for its care and preservation is assumed by all concerned in handling it.

*Q.* What duties relative to ammunition records must a chief of section of an ammunition train perform in the field? *A.*—

(1) He may be required to draw and sign for the ammunition at the distributing point.

(2) He must obtain a receipt for that issued to the batteries, and return same to the munitions officer.

*Q.* What other duties has the chief of section in this connection? *A.*—

(1) He must keep himself informed of available ammunition at the distributing point.

(2) He must act as liaison agent between the battalion munitions officer and the firing batteries, keeping the former informed of ammunition on hand, rate of expenditure, care and preservation, and furnishing any additional data he may require.

*Q.* What should be done in the way of checking?—*A.* Be sure to count and inspect everything signed for. When complete rounds of separate loading ammunition are called for, a check for each component of the round should be made.

*Q.* What else should be watched in checking ammunition?—*A.* See that it is all loaded. Know how many rounds to put on a truck and how to load the truck. See that it is the kind called for.

# INDEX

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|   | Paragraph  | Page       |
|---|------------|------------|
| Acoustic correctors .....               | 147        | 304        |
| Adjustment of fire .....                | 67-69      | 112        |
| Aircraft:                               |            |            |
| Characteristics .....                   | 76         | 126        |
| Classes .....                           | 73         | 124        |
| Indication .....                        | 77         | 137        |
| Low-flying, protection against .....    | 156        | 325        |
| Missions .....                          | 74         | 125        |
| Naval .....                             | 75         | 126        |
| Spotting .....                          | 79-85      | 139        |
| Types .....                             | 73         | 124        |
| Alarms, dissemination .....             | 58, 59     | 85, 87     |
| Altimeter .....                         | 64         | 100        |
| Ammeters .....                          | 143        | 299        |
| Ammunition:                             |            |            |
| Advanced .....                          | 165, 166   | 346, 351   |
| Automatic weapons .....                 | 114-131    | 232        |
| Care .....                              | 96         | 207        |
| Definitions .....                       | 154        | 322        |
| Handling .....                          | 165        | 346        |
| Magazine .....                          | 96         | 207        |
| Preparation for firing .....            | 97         | 208        |
| Procuring .....                         | 165        | 346        |
| Records and reports .....               | 166        | 351        |
| Storage .....                           | 96         | 207        |
| Antiaircraft spotting set:              |            |            |
| Film development .....                  | 83         | 161        |
| Film viewer .....                       | 85         | 167        |
| Installation of theodolites .....       | 82         | 159        |
| Maintenance .....                       | 79         | 139        |
| Operation .....                         | 79         | 139        |
| Projector equipment .....               | 84         | 165        |
| Time-interval device .....              | 80, 81     | 156, 158   |
| Assignment of topics .....              | 2          | 3          |
| Axles .....                             | 11         | 18         |
| Ballistic wind .....                    | 88, 107    | 178, 218   |
| Battery, storage .....                  | 8, 18, 44  | 15, 23, 57 |
| Battery ignition .....                  | 16         | 22         |
| Bivouac, organization of position ..... | 155-158    | 323        |
| Bore sighting .....                     | 103        | 212        |
| Brakes, motor vehicle .....             | 12, 20, 43 | 12, 25, 54 |
| Calibration .....                       | 102        | 211        |
| Camera spotting .....                   | 79-85      | 139        |
| Camouflage .....                        | 155        | 323        |

## INDEX

|                                     | Paragraph  | Page       |
|-------------------------------------|------------|------------|
| Camshaft.....                       | 3          | 6          |
| Carburetor.....                     | 4, 15, 40  | 8, 22, 52  |
| Circuits, searchlight matériel..... | 140        | 296        |
| Circuits, telephone.....            | 46-49      | 59         |
| Clutch.....                         | 10, 19, 43 | 15, 25, 54 |
| Communications:                     |            |            |
| Alarms.....                         | 58, 59     | 85, 87     |
| Message centers.....                | 55, 56     | 82, 83     |
| Messages:                           |            |            |
| Encoding and decoding.....          | 56         | 83         |
| Flash.....                          | 58, 59     | 85, 87     |
| Panels.....                         | 50         | 74         |
| Systems.....                        | 46-49      | 59         |
| Telephones:                         |            |            |
| Description of circuit.....         | 47         | 61         |
| Circuits.....                       | 49         | 71         |
| Field systems, installation.....    | 51-53      | 74         |
| Linemen.....                        | 57         | 85         |
| Location of faults.....             | 54         | 80         |
| Short circuits.....                 | 54         | 80         |
| Switchboard operators.....          | 57         | 85         |
| Switchboards.....                   | 48         | 64         |
| Tests for grounds.....              | 54         | 80         |
| Concealment:                        |            |            |
| Discipline.....                     | 155        | 323        |
| Guns.....                           | 127        | 263        |
| Telephones.....                     | 53         | 78         |
| Control stations, searchlights:     |            |            |
| General Electric.....               | 136        | 286        |
| Sperry.....                         | 135        | 282        |
| Convoy.....                         | 30, 34-36  | 38, 43     |
| Cooling system, engine.....         | 7, 21, 39  | 14, 26, 51 |
| Corrections, final firing data..... | 105        | 214        |
| Cycle, engine.....                  | 3          | 6          |
| Data, firing, final.....            | 105        | 214        |
| Data transmission systems:          |            |            |
| Care.....                           | 113        | 230        |
| M3.....                             | 111        | 227        |
| M4.....                             | 110        | 223        |
| Maintenance.....                    | 113        | 230        |
| Power plant.....                    | 112        | 228        |
| Definitions.....                    | 152-154    | 314        |
| Developing, theodolite film.....    | 83         | 161        |
| Differential, vehicle.....          | 10         | 15         |
| Directors:                          |            |            |
| M3.....                             | 66         | 110        |
| M3A1.....                           | 66         | 110        |
| M4.....                             | 65         | 101        |
| Drivers, training.....              | 28         | 32         |

## INDEX

|   | Paragraph     | Page          |
|---|---------------|---------------|
| Electricity.....                                    | 163           | 341           |
| Emplacement, machine guns and 37-mm guns.....       | 128           | 265           |
| Engine, internal combustion:                        |               |               |
| Cooling system.....                                 | 7, 21, 39     | 14, 26, 51    |
| Data transmission system.....                       | 112           | 228           |
| Field maintenance.....                              | 38-45         | 49            |
| Gasoline feed.....                                  | 4, 15, 40     | 8, 22, 52     |
| Generators.....                                     | 9             | 15            |
| Governors.....                                      | 23            | 27            |
| Ignition.....                                       | 5, 16, 17, 41 | 10, 22, 52    |
| Inspection.....                                     | 14-18, 21, 23 | 20, 26, 27    |
| Lubrication.....                                    | 6, 42         | 12, 53        |
| Maintenance.....                                    | 14-18, 21, 23 | 20, 26, 27    |
| Storage battery.....                                | 8, 18, 44     | 15, 23, 57    |
| Theory.....   | 3, 38         | 6, 49         |
| Exposure meters.....                                | 79            | 139           |
| Feed system, engine.....                            | 4             | 8             |
| Film, developing.....                               | 83            | 161           |
| Film viewer.....                                    | 85            | 167           |
| Final firing data.....                              | 105           | 214           |
| Fire, adjustment.....                               | 67-69         | 112           |
| Fire precautions, garages.....                      | 25            | 29            |
| Firings:  |               |               |
| Calibration.....                                    | 102, 108      | 211, 219      |
| Final data.....                                     | 105           | 214           |
| Trial shots.....                                    | 101, 108      | 210, 219      |
| Verification.....                                   | 102, 108      | 211, 219      |
| Fuel pump, engine.....                              | 4, 40         | 8, 52         |
| Fuze setters.....                                   | 94, 101       | 204, 210      |
| Garage procedure.....                               | 24-26         | 28            |
| Gasoline feed system.....                           | 4, 15, 40     | 8, 22, 52     |
| Gear.....   | 10            | 15            |
| Gear, steering.....                                 | 13            | 19            |
| Generators.....                                     | 9, 18         | 15, 23        |
| Glossary.....                                       | 152-154       | 314           |
| Governors.....                                      | 23            | 27            |
| Gun section.....                                    | 95            | 207           |
| Guns:   |               |               |
| Fuze setters.....                                   | 94            | 204           |
| Inspection.....                                     | 93            | 199           |
| Machine. (See Machine guns.)                        |               |               |
| Maintenance.....                                    | 93            | 199           |
| 105-mm antiaircraft.....                            | 92, 93, 100   | 194, 199, 210 |
| Preparation for service practice.....               | 98-100        | 209           |
| 37-mm. (See 37-mm gun.)                             |               |               |
| 3-inch antiaircraft. (See 3-inch antiaircraft gun.) |               |               |
| Height finders:                                     |               |               |
| Check.....  | 63            | 99            |
| M1.....   | 61            | 91            |
| M2.....   | 62            | 98            |

## INDEX

|  | Paragraph | Page    |
|--|-----------|---------|
| <b>Ignition, engine:</b>                       |           |         |
| Battery .....                                  | 16        | 22      |
| Field maintenance .....                        | 41        | 52      |
| Magnetos .....                                 | 17        | 22      |
| System .....                                   | 5         | 10      |
| <b>Inspections:</b>                            |           |         |
| Guns .....                                     | 93        | 199     |
| Motor vehicles .....                           | 14-23, 33 | 20, 42  |
| Internal combustion .....                      | 3, 38     | 6, 49   |
| Lamps, searchlight .....                       | 141       | 297     |
| Loads, vehicle .....                           | 27        | 30      |
| Lubrication, engine .....                      | 6, 42     | 12, 53, |
| <b>Machine guns:</b>                           |           |         |
| Caliber .30 .....                              | 114       | 232     |
| Caliber .50 .....                              | 115       | 235     |
| Care .....                                     | 117       | 245     |
| Cleaning .....                                 | 117       | 245     |
| Emplacement .....                              | 128       | 265     |
| Headspace adjustment .....                     | 119       | 249     |
| Malfunctioning .....                           | 120       | 249     |
| Mount .....                                    | 116       | 243     |
| Packing barrel .....                           | 118       | 247     |
| Position, selection .....                      | 127       | 263     |
| Preparation for service practice .....         | 129-131   | 267     |
| Replacement of parts .....                     | 121       | 250     |
| Squad, duties .....                            | 126       | 263     |
| Magazines .....                                | 96        | 207     |
| Magnetos .....                                 | 17        | 22      |
| <b>Map reading:</b>                            |           |         |
| Data as to roads, bridges, etc. ....           | 162       | 340     |
| Following route indicated .....                | 161       | 339     |
| Location of position by coordinates .....      | 160       | 336     |
| Scales, contours, and conventional signs ..... | 159       | 329     |
| March rules and discipline .....               | 34-36     | 43      |
| Message centers .....                          | 55        | 82      |
| <b>Messages:</b>                               |           |         |
| Encoding and decoding .....                    | 56        | 83      |
| Flash .....                                    | 58, 59    | 85, 87  |
| Meteorological .....                           | 86        | 170     |
| Records and reports .....                      | 59        | 87      |
| <b>Meteorological section:</b>                 |           |         |
| Instruments .....                              | 87        | 172     |
| Message .....                                  | 86        | 170     |
| Plotting .....                                 | 88        | 178     |
| Use of tables .....                            | 89        | 183     |
| <b>Motor transportation:</b>                   |           |         |
| Convoy .....                                   | 30        | 38      |
| Drivers .....                                  | 28        | 32      |
| Field maintenance .....                        | 38-45     | 49      |
| Inspections, road .....                        | 33        | 42      |
| March rules and discipline .....               | 34-36     | 43      |

|  | Paragraph         | Page                 |
|--|-------------------|----------------------|
| Motor transportation—Continued.                        |                   |                      |
| Parking .....  | 32                | 42                   |
| Records and reports .....                              | 37                | 47                   |
| Rules of the road .....                                | 29                | 36                   |
| Speed .....  | 31                | 41                   |
| Motor vehicles:  |                   |                      |
| Axles .....  | 11                | 18                   |
| Brakes .....   | 12, 20, 43        | 12, 25, 54           |
| Engines. ( <i>See</i> Engine, internal combustion.)    |                   |                      |
| Field maintenance .....                                | 38-45             | 49                   |
| Gear .....   | 10, 43            | 15, 54               |
| Inspection .....                                       | 14-23, 33         | 20, 42               |
| Loads .....  | 27                | 30                   |
| Maintenance .....                                      | 14-23             | 20                   |
| Shop practices .....                                   | 24                | 28                   |
| Steering gear .....                                    | 13                | 19                   |
| Transmission of power .....                            | 10, 19, 43        | 15, 25, 54           |
| Wheels .....   | 11, 20, 43        | 18, 25, 54           |
| Observation instruments .....                          | 69                | 118                  |
| 105-mm antiaircraft gun .....                          | 92, 93, 100       | 194,<br>199, 210     |
| Orientation .....                                      | 103               | 212                  |
| Panels .....   | 50                | 74                   |
| Parking, motor vehicle .....                           | 32                | 42                   |
| Photography, theodolite .....                          | 79-85             | 139                  |
| Plotting, meteorological message .....                 | 88                | 178                  |
| Position, selection, machine guns and 37-mm guns ..... | 127               | 263                  |
| Position finding:                                      |                   |                      |
| Apparatus:   |                   |                      |
| Altimeter .....  | 64                | 100                  |
| Directors .....  | 65                | 101                  |
| Height finders, stereoscopic .....                     | 61-63             | 91                   |
| Definition .....                                       | 60                | 89                   |
| Orientation .....                                      | 70-72             | 121                  |
| Transit .....  | 71, 72            | 122, 123             |
| Power plant:   |                   |                      |
| Data transmission system .....                         | 112               | 228                  |
| Searchlight .....                                      | 137               | 288                  |
| Projectiles:   |                   |                      |
| Nonstandard conditions, effect on flight .....         | 107               | 218                  |
| Preparation for firing .....                           | 97                | 208                  |
| Projector equipment .....                              | 84                | 165                  |
| Protection .....                                       | 155-158           | 323                  |
| Raids, protection against .....                        | 158               | 327                  |
| Range, adjustment .....                                | 67-69             | 112                  |
| Range section:   |                   |                      |
| Duties .....   | 104               | 214                  |
| Elementary gunnery .....                               | 105-108           | 214                  |
| Records and reports .....                              | 109               | 220                  |
| Records and reports .....                              | 59, 109, 130, 166 | 87, 220,<br>268, 351 |
| Repairs, field, motor vehicle .....                    | 45                | 58                   |

## INDEX

|                             | Paragraph | Page     |
|-----------------------------|-----------|----------|
| Road inspections.....       | 33        | 42       |
| Road rules.....             | 29        | 36       |
| Sabotage.....               | 158       | 327      |
| Safety precautions:         |           |          |
| Ammunition.....             | 165       | 346      |
| Automatic weapons.....      | 131       | 269      |
| Fire in garages.....        | 26        | 30       |
| Searchlights:-              |           |          |
| Adjustment of parts.....    | 139       | 295      |
| Care.....                   | 139       | 295      |
| Characteristics.....        | 132       | 271      |
| Concealment.....            | 151       | 311      |
| Control stations.....       | 135, 136  | 272, 282 |
| Definition.....             | 153       | 321      |
| Dismantling.....            | 144       | 299      |
| Emplacements.....           | 151       | 311      |
| Employment of section.....  | 151       | 311      |
| General Electric.....       | 134, 136  | 277, 286 |
| Maintenance.....            | 139       | 295      |
| Organization, tactical..... | 150       | 311      |
| Orientation.....            | 138       | 295      |
| Power plants.....           | 137       | 288      |
| Sperry.....                 | 133, 135  | 272, 282 |
| Sychronization.....         | 138       | 295      |
| Troubles and remedies:      |           |          |
| Ammeters.....               | 143       | 299      |
| Circuits.....               | 140       | 291      |
| Generator brushes.....      | 144       | 299      |
| Lamps.....                  | 141       | 297      |
| Minor repairs.....          | 144       | 299      |
| Preparation.....            | 144       | 299      |
| Switches.....               | 142       | 298      |
| Voltmeters.....             | 143       | 299      |
| Types.....                  | 132       | 271      |
| Setter, fuze.....           | 94        | 204      |
| Shelter.....                | 157       | 326      |
| Shop practices.....         | 24        | 28       |
| Signals—                    |           |          |
| Driver's, in convoy.....    | 35        | 45       |
| Firing.....                 | 131       | 269      |
| Visual.....                 | 50        | 74       |
| Sound lag.....              | 145       | 300      |
| Sound locaters:             |           |          |
| Acoustic correctors.....    | 147       | 302      |
| Adjustment.....             | 149       | 310      |
| Care.....                   | 149       | 310      |
| Corrections.....            | 146       | 301      |
| Definitions of terms.....   | 153       | 321      |
| Description.....            | 145, 147  | 300, 302 |
| Maintenance.....            | 149       | 310      |

## INDEX

| Sound locaters—Continued.                 | Paragraph | Page       |
|---|-----------|------------|
| Models in service.....                    | 145       | 300        |
| Personnel.....                            | 146       | 301        |
| Use.....                                  | 145       | 300        |
| Speed laws.....                           | 31        | 41         |
| Spotting.....                             | 67-69     | 112        |
| Spotting instrument, flank.....           | 68        | 117        |
| Steering gear.....                        | 13, 22    | 19, 26     |
| Stereoscopic height finder.....           | 61-63     | 91         |
| Storage battery.....                      | 8, 18, 44 | 15, 23, 57 |
| Supervision, automatic weapon firing..... | 131       | 269        |
| Supplies, motor vehicle.....              | 45        | 58         |
| Supply, definitions.....                  | 154       | 322        |
| Switchboard operators.....                | 57        | 85         |
| Switchboards.....                         | 48        | 64         |
| Switches, searchlight.....                | 142       | 298        |
| Tables, meteorological.....               | 89        | 183        |
| Target practice, records and reports..... | 109       | 220        |
| Telephones:                               |           |            |
| Circuits.....                             | 46-49     | 59         |
| Concealment.....                          | 53        | 78         |
| Faults, location.....                     | 54        | 80         |
| Field installation.....                   | 51-53     | 74         |
| Grounds, tests.....                       | 54        | 80         |
| Linemen.....                              | 57        | 85         |
| Protection.....                           | 53        | 78         |
| Short circuits.....                       | 54        | 80         |
| Switchboard operators.....                | 57        | 85         |
| Switchboards.....                         | 48        | 64         |
| Telescopes.....                           | 69        | 118        |
| Theodolites:                              |           |            |
| Developing film.....                      | 83        | 161        |
| Film viewer.....                          | 85        | 167        |
| Installation.....                         | 82        | 159        |
| Maintenance.....                          | 79        | 139        |
| Projector equipment.....                  | 84        | 165        |
| Time interval device.....                 | 80, 81    | 156, 158   |
| 37-mm gun:                                |           |            |
| Adjustment of matériel.....               | 130       | 268        |
| Care and preservation.....                | 124       | 259        |
| Check.....                                | 130       | 268        |
| Disassembly and assembly.....             | 123       | 253        |
| Emplacement.....                          | 128       | 265        |
| Functioning.....                          | 122       | 251        |
| Mount.....                                | 125       | 262        |
| Preparation for service practice.....     | 129-131   | 267        |
| Safety precautions.....                   | 131       | 269        |
| Section, duties.....                      | 126       | 263        |
| Selection of position.....                | 127       | 263        |

## INDEX

|                                       | Paragraph  | Page       |
|---------------------------------------|------------|------------|
| 3-inch antiaircraft gun:              |            |            |
| Inspection.....                       | 93         | 199        |
| M3.....                               | 90         | 186        |
| M1917 (fixed).....                    | 91         | 193        |
| Maintenance.....                      | 93         | 199        |
| Preparation for service practice..... | 98-100     | 209        |
| Time interval device, theodolite:     |            |            |
| PH-35.....                            | 80         | 156        |
| PH-103.....                           | 91         | 193        |
| Topic assignment.....                 | 2          | 3          |
| Traffic rules, convoy.....            | 36         | 46         |
| Trajectory chart.....                 | 105        | 214        |
| Transit.....                          | 70-72      | 121        |
| Transmission, data.....               | 110-113    | 210        |
| Transmission, power, vehicle.....     | 10, 19, 43 | 15, 25, 54 |
| Traverse.....                         | 70-72      | 121        |
| Trial shots.....                      | 101, 106   | 210, 217   |
| Valves, engine.....                   | 3          | 6          |
| Verification firings.....             | 102        | 211        |
| Visual signaling.....                 | 50         | 74         |
| Voltmeters.....                       | 143        | 299        |
| Wheels, vehicles.....                 | 11, 20, 43 | 18, 25, 54 |
| Wind, ballistic.....                  | 88, 107    | 178, 218   |
| Wrenches.....                         | 24         | 28         |

[A. G. 062-11 (7-29-41).]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,  
*Chief of Staff.*

OFFICIAL:

J. A. ULIO,  
*Major General,  
The Adjutant General.*

DISTRIBUTION:

I Bn and H 4 (3) ; IC 4, as follows:

AA gun btry. (20).  
AA AW btry. (20).  
AA Slt btry. (30).  
AA Hq btry. regt. (15).  
AA Hq btry. bn. (10).  
HD Slt btry. (5).

Replacement Training Center:

AA gun, AW & Slt btry. (30).  
Hq. Btry. (15).

(For explanation of symbols see FM 21-6.)



















